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MILITARY HYDROLOGY

RESEARCH & DEVELOPMENT BRANCH

Corps of Engineers

Dept. of Army

Washington District

CONFIDENTIAL

SPECIAL STUDY S-52-2

EMS RIVER

ARTIFICIAL FLOODING

POTENTIALITIES

CONFIDENTIAL
SECURITY INFORMATION

Prepared by
Military Hydrology R & D Branch
Engineering Division
Washington District Corps of Engineers
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SPECIAL STUDY S-52-2

BUG RIVER

ARTIFICIAL FLOODING POTENTIALITIES

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SECTION I

INTRODUCTION

1-01 ASSIGNMENT.

This special study was assigned to the Military Hydrology Research and Development Branch, Engineering Division, Washington District, by letter from Office, Chief of Engineers, ENGWE, to the Division Engineer, North Atlantic Division; subject, "Military Hydrology R & D Project No. 8-72-12-001; Special Assignments," dated 27 May 1952.

1-02 PURPOSE AND SCOPE.

a. This report presents information regarding the hydraulic effects and nature of artificial flooding potentialities in the Ems River basin. It consists largely of a compilation and consolidation of information presented in various intelligence documents and technical publications, with certain supplementary analyses and discussions. Additional studies are needed to adequately cover the subject for general military requirements.

b. The report is designed to furnish basic data and results of analyses needed to answer questions concerning:

(1) Normal and extreme stages and surface velocity including duration, at key stations on the Ems River.

(2) Stream characteristics including gradients, depths and widths of channel and flood plain in various reaches of the waterways of the basin.

(3) Data concerning locations and zero elevations of gaging (pegel) stations.

(4) Data concerning location and dimensions of navigation structures, levees and bridges on the waterways of the Ems River basin.

(5) The extent of flooding created by erection of temporary dams on the Ems River.

(6) The magnitude and duration of flood waves and flow variations created by destruction or operation of stream control structures and the effect on bridging, crossing, and navigation of the Ems River.

1-03 ARRANGEMENT:

This report is subdivided as follows:

1-04 DEFINITION OF TERMS.

a. Equivalent English-Metric Terms. Both the English and metric systems are used in this report. Conversion factors are presented for reference in Table 1.

b. Hydrologic Terms and Abbreviations. The following abbreviations are used in this report: l for liters, m for meters, km for kilometers, m^3 for cubic meters, m/s for meters per second, m^3/s for cubic meters per second. Abbreviations applicable to stage and discharge are defined in Table 2.

1-05 REFERENCES.

All references cited in this report are listed in the bibliography following Section V of the text.

SECTION II

DRAINAGE BASIN CHARACTERISTICS AND DEVELOPMENTS

2-01 GENERAL.

a. The Ems River is the westernmost of the large rivers in Germany. It is located in the provinces of Hannover and Westfalene in the northwest part of Germany near the Holland border. The river flows northward to Emden emptying into Dollart Bay, an estuary of the North Sea. The Ems River forms the basis of a large canal system, including the Dortmund-Ems Canal which follows the Ems valley for much of its course. A general map is shown on Plate 1 and a more detailed location plan is included on Plate 2. Detailed descriptions are contained in Exhibits A and B and in References 1 and 2 listed in the bibliography of this report.

b. This report is confined to consideration of the main stem of the Ems River, the Dortmund-Ems canal, and the canals on the left side of the Ems River east of the Germany-Holland border.

2-02 TOPOGRAPHY.

The general topography of the Ems River basin is illustrated on the Physiographic Diagram shown as Plate 3. The Ems River rises on the southwestern slope of the Teutoburger Wald at an altitude of about 130 m and flows westward across the shallow land depression of the "Muenster Bay," emerging onto the North German Plain through a steep, shallow gorge near Rheine. There it continues northward in a sandy valley between moorlands. The lower reaches cross flat low-lying reclaimed marshlands and enter the broad, shallow Dollart Bay, a wide estuary of the North Sea. The divide between the Ems and Lippe Rivers is indeterminate and is crossed by the Dortmund-Ems Canal. Detailed topographic descriptions appear in the documents listed as References 1 and 3 in the Bibliography.

2-03 GEOLOGY.

The Ems River meanders between low hills of "Geest," (heath and moorland) through an alluvial valley 1 to 5 km wide. The river-bed consists almost entirely of sand, with outcrops of chalk and chalk-marl near the Rheine gorge and with patches of clay in the tidal reaches. Detailed descriptions of geologic conditions are contained in References 1 and 3.

2-04 DRAINAGE AREAS.

The drainage area of the Ems River and its tributaries is 12,482 km², the smallest drainage basin of the major German rivers. For comparison, the drainage area of the Weser River is 45,548 km².

Drainage areas at key gaging stations on the Ems River are included in Tables 3 and 4. The areas drained by the Ems River and its major tributaries are as follows:

River	Location	Drainage area km^2
Werse	Ems confluence	765
Aa	" "	933
Hase	" "	3126
Leda	" "	2203
Ems	Werse confluence	1870
"	Aa "	3871
"	Hase "	5079
"	Leda "	9499
"	Mouth	12482

2-05 GRADIENTS AND PROFILES.

a. Gradients are indicated on the profiles shown on Plates 4-10, inclusive. Following are listed average gradients of the Em River:

Reach	River Km	Avg. Gradient per 10,000
Source - Beiwinkels Mill	430-414	32
Beiwinkels Mill - Werse River	414-311	4.5
Werse River - Rheine	311-251	1.6
Rheine - Bentlage	251-246	9.6
Bentlage - Meppen	246-176	2.2
Meppen - Leda River	176- 78	1.6
Leda River - Mouth	78- 0	0.7

b. Elevations in this report are in meters above "Normal Null" (N.N.), the zero of the German land survey datum, corresponding to mean sea level on the Baltic coast and slightly below mean sea level on the German North Sea Coast. In certain Dutch and other publications, elevations may be referenced to "Nauwkeurigheids Amsterdamsch Peil" (N.A.P.), the modern Dutch survey datum. The zero elevation of the German N.N. datum lies 0.012 m above the zero of the Dutch N.A.P. datum.

c. River distances along the Ems River are expressed in this report as kilometers above Borkum Island, the mouth of the Ems River in Dollart Bay. In Exhibit B, distance is measured in a downstream direction, and three different kilometrage zero points are employed for different reaches: at the source, at Greven, and at Meppen. The systems are indicated on the General Map, Plate 1. In certain other publications, such as Reference 2, distances are measured upstream or downstream, from critical navigation locations. The conversion factors are variable as the bases of measurement are different.

d. Distances along the Dortmund-Ems Canal are measured in kilometers northward from Dortmund and are so shown on the Location Plan, Plate 2 and on the Profile, Plate 7. Kilometrage of other canals are measured from their junction with main canal intersections as indicated on the profiles of Plates 7 to 10.

2-06 CHANNEL DEPTHS.

a. The depth of the Ems River is shallow and fordable in some upriver locations but fairly deep in the pools above the dams. Detailed depth data are contained in Exhibit A, on Plates 4 to 6, and in References 1 and 2. A tabulation of representative average depths along the Ems River follows:

Reach	River km	Avg. Depth at MW(m)
Source - Werse River	430-311	0.6 (2-4 m at dams)
Werse River - Rheine	311-251	0.9-4
Rheine - Meppen	251-176	1.5-4
Meppen - Leda River	176- 78	1.2-4
Leda River - Emden	78- 51	5.5-6.5
Emden - Mouth	51- 0	10

b. The depth of the Dortmund-Ems Canal was originally 2.5 m but is being increased to 3.5 m, the standard depth for major German navigation canals. Minor navigation canals, such as those on the left side of the Ems River, are 1.5 to 2 m deep. Depths are indicated on the canal profiles, Plates 7 to 10 and in Appendixes A and B.

2-07 CHANNEL AND FLOOD PLAIN WIDTHS.

a. Widths of channel along the Ems River are shown in Exhibit A. The widths of valley subject to flooding can be estimated by reference to the General Map, Plate 1. Following is a general indication of the channel and flood plain widths:

Reach	River km	Channel width (m)	Flood Plain Width (km)
Source - Werse River	430-311	7.5-25	0.5-1.5
Werse River - Rheine	311-251	20-30	0.5-1.5
Rheine - Meppen	251-176	40-60	0.5-3
Meppen - Leda River	176- 78	50-300	1.5-7
Leda River - Emden	78- 51	550	10-15

b. The Dortmund-Ems Canal has a surface width of 30 to 40 meters and the navigation canals on the left side of the Ems are 13 to 16 m wide. Detailed data upon canal widths are contained in References 1 to 5.

2-08 NAVIGATION.

a. The Ems River forms the basis of an extensive navigation canal system. The Dortmund-Ems Canal follows the Ems Valley from Dortmund to Emden, and in part is a unit of the Mittelland Canal system which extends across Germany from the Rhine River to the Elbe River, as is shown on Plates 1 and 10. The Kuesten Canal links the Dortmund-Ems Canal and the Weser River estuary. Description of the most important navigable waterways is contained in paragraph 2-12 and in Exhibit B; locations are shown on plates 1 and 2 and profiles are presented as Plates 4-10. Additional information regarding navigation may be found in the documents listed as References 1-49 in the Bibliography.

b. The Upper Ems River can be navigated in the reach from the Schoneflieth Dam (km 298) to Hanekenfaehr Dam (km 214) by the so-called "Ems-Puenten," which are 26 m long by 5.3 m wide, and which are normally loaded to 80 tons* of their full 150 ton-capacity so as not to exceed a 0.8 m draft. Traffic in that section is insignificant. The Middle Ems from Hanekenfaehr Dam to the Hase River confluence at Meppen (km 176) contains so many bends that it now has been practically abandoned for navigation in favor of the adjacent reach of the Dortmund-Ems Canal. The Lower Ems from Meppen to Papenburg (km 92) has been canalized as part of the Dortmund-Ems Canal, and is maintained to a minimum depth of 2 m by dredging in order to permit passage of 1000 ton-barges. Papenburg is accessible to sea-going vessels of 3.5 m draft. The channel project depth at Leerot (km 77) is 4.1 m, and between that port and Emden is 5.5 m. A lateral canal parallels the Ems River between Oldersum (km 62) and Emden (km 51) and is used by river boats during heavy weather to avoid dangerous conditions on the Ems River. Detailed navigation data are contained in Reference 2.

c. The Ems River below Emden rarely freezes over, but drift ice forms during severe winters. The reaches of the Ems River above Emden sometimes freeze with ice up to 30 cm thick, but interruption of navigation due to ice is an exceptional occurrence. Navigation on the smaller canals is suspended for periods of 2 to 3.5 months during severe winters. Navigation on the Ems River proper is interrupted for an average of 27 days annually due to ice or floods. Following is a tabulation of icing conditions on the Ems River at Lingen and Mesum:

	Lingen (km 208)	Mesum (km 260)
Mean number of days with ice	10.6	17.4
Maximum number of days with ice	34	37
Extreme occurrence of first ice	27 Nov.	20 Nov.
Extreme occurrence of last ice	3 Mar.	26 Feb.

*Metric tons

2-09 REGULATION.

Stages and flow on the Ems River may be regulated by operation of the locks and dams for navigation, power generation, and irrigation. Limited diversion of water between the Ems River, Dortmund-Ems Canal, and the other canals is accomplished by pumping and by operation of control structures. Detailed description of flow regulation on the Ems River and adjacent canals is included in Exhibit B and in References 1 and 2. Locations of structures are shown on the maps and profiles, Plates 1 to 10, inclusive.

2-10 DAMS AND RESERVOIRS.

a. Reservoirs. No high dams or large reservoirs exist in the Ems River basin, except for a 9 million m^3 storage reservoir in the Soeste river valley near Freisoythe, south of the Kuesten Canal.

b. Navigation Dams. Detailed description of the numerous navigation locks and dams located on the various streams and canals of the Ems River basin is contained in Exhibits A and B, and locations are shown on the maps, Plates 1 and 3, and on the profiles, Plates 4 to 10.

c. Mill Dams. On the Ems River upstream from Rheine (km 251), there are located 15 small mill dams of minor importance. Descriptive data appears in Exhibit A and locations of the most important structures are shown on the profiles, Plate 4.

2-11 LEVEES.

No extensive levee system exists in the non-tidal reaches of the Ems River; a number of short local levees built to about 2 to 3 m above the channel bed suffice to protect adjacent farmland from summer floods. In the tidal reaches, a complete system of levees, canals, and pump stations is maintained to prevent re-flooding of the large areas of low-lying reclaimed land along the river. The main levees in that region are 4 to 5 m high.

2-12 CANALS.

a. The Dortmund-Ems Canal provides a part of the connecting link for barge traffic between the Rhine River and the North Sea and is an important part of the Mittelland Canal system. Enlargement of the canal to a project depth of 3.5 m has been undertaken to permit use of 1500-ton boats. Work was started about 1930 and was expected to be finished by 1942, but was not complete in 1945, the date of latest information. Location plan, profile, and typical cross-sections of the Dortmund-Ems Canal are shown on Plates 2, 7, and 11, respectively. Detailed navigation data are contained in References 1 through 9.

*Metric tons

b. The Ems-Seiten Canal is a lateral navigation canal bypassing the Ems River and Dortmund-Ems Canal from Hessote to Papenburg. Construction was started prior to the war, but abandoned. No information is available on the current status of construction. The proposed dimensions of the canal are 40 m wide and 3.5 m deep, sufficient for 1500 ton barges. Location of the proposed canal is shown on Plate 2, and the planned profile on Plate 7.

c. The canals on the left side of the Ems River provide for barge traffic between the German and Holland canal systems. Barges used are 27 m long by 5.8 m wide and normally carry 00 tons, but can be loaded to 150*tons for travel on the Ems-Vechte Canal. The Vechte River traffic is restricted to 20 ton*capacity boats. References 1 and 2 contain detailed information. See Plates 1 and 2 for locations, Plates 8 and 9 for profiles, and Appendix B for additional description.

2-13 BRIDGES.

Locations and clearances (wherever data are available) of major bridges across the Ems River are shown on the profiles of Plates 4 to 6, inclusive. Tabulations of pertinent bridge data are included as Appendix A and contained in References 1, 2, and 10 of the Bibliography. Reliable information upon post-war reconstruction subsequent to 1945 is not available.

*Metric tons

SECTION III

HYDROLOGIC CHARACTERISTICS

3-01 GENERAL.

Information regarding Ems River stages and discharges, stage duration and seasonal variation and current velocities are herein presented in generalized graphical form insofar as practicable to facilitate application of the data to specific military problems. References cited should be utilized for supplementary data.

3-02 CLIMATOLOGY.

Climatological data for the region covered by this report may be found in References 2 and 3. The annual rainfall in North Germany decreases from about 700 mm on the North Sea Coast to about 600 mm at Hanover and to about 500 mm at Posen and increases about 10 mm for each 100 meters of altitude. The maximum rainfall occurs in summer, but due to greater summer-time infiltration and evaporation losses the rate of runoff is greatest during the winter months.

3-03 STREAM GAGING STATIONS.

A number of gages have been established on the Ems River and its tributaries and records are published for the more important stations. Locations of gages of primary importance are shown on the General Map, Plate 1 and on the stream profiles, Plates 4 to 6. Statistical records for the gaging stations are published in the German Hydrologic Yearbook, References 11 and 12.

3-04 RIVER STAGES.

a. Records. Data regarding the maximum, mean, and minimum stages of record at key gaging stations on the Ems River are presented in Tables 3 and 4, together with other pertinent data. Mean daily stages and other gage data may be found in References 11 and 12.

b. Seasonal Variation. The range of stages for each month of the year is indicated in Tables 3 and 4. It may be observed that the average stages for stations in non-tidal reaches during the winter, November through April, are consistently higher than the corresponding average stages during the summer months, May through October. The maximum MHW, MW, and MNW occur in January or February and the minimum in July through September. The occurrence of higher stages during winter can also be observed on the Stage Duration Curves of Plate 12.

c. Stage Duration. Stage duration curves for stations on the Ems River, showing the percent of time a given stage was equalled or exceeded during the period of record, are presented on Plates 12 and 13. It may be observed that the mean stage (MW) shown on Tables

3 and 4, (representing an arithmetical average) differs from the median stage, that stage, shown on Plates 12 and 13, which has been equalled or exceeded 50% of the time. That difference is insignificant for stations in the tidal reaches, but is appreciable for some non-tidal stations. The following table of yearly mean and median stages shows the difference for key stations.

Station	Mean Stage (cm) (MW) (Tables 3 & 4)	Median Stage (cm) (50% of time) (Plates 12 & 13)
Greven	248	210
Rheine	226	190
Versen	182	150
Papenburg (High-tide)	641	650
(Low-tide)	478	478
Emden (High-tide)	628	630
(Low-tide)	327	320

d. Tide Variations. The tidal range between mean high tide (MThw) and mean low tide (MTnw), as indicated in Tables 3 and 4, varies from about 3 m. at Emden to about 1.6 m at the upstream gage at Papenburg. It may be observed from those tables and also from the profile of Plate 6, that the high high-tide stages (HHThw, HThw, and MHThw) are higher at the gages nearer the sea than at those farther upstream. In the case of the low-tide stages a converse situation is evidenced. The stage duration curves of Plate 13 present a graphical indication of the tidal variati

3-05 RIVER DISCHARGE.

a. Discharge Records. Mean daily discharge, monthly and annual mean and extreme discharges are contained in the document listed as Reference 11 in the Bibliography. A tabulation of statistical discharge data at key stations on the Ems River is presented in Table 5. The duration of discharge would be practically identical with the trends evidenced by the stage duration curves of Plates 13 and 14 and described in paragraph 3-04c. The expected approximate duration of a given flow can be determined by obtaining the corresponding stage from the discharge-stage relation curves of Plate 14 to enter the duration curves of Plate 12. Median flows equaled or exceeded 50 percent of the time, established by application of the stage-discharge relation of Plate 14 to the stage duration curve of Plate 12 are tabulated below:

Station	River km	Median Flow (m^3/s) Winter	Summer	Year
Greven	295	25	7	15
Rheine	250	30	9	18
Versen	168	60	20	35

b. Stage-discharge Relation. Average stage-discharge relation curves for 3 key stations on the Ems River are presented on Plate 14. These curves were estimated from discharge measurements and from equivalent stage-discharge data contained in References 11 and 12 of the Bibliography.

3-06 RIVER VELOCITIES.

a. General. The velocity of stream flow varies according to the conformation of the river bed, the depth, obstructions and restrictions, variation in slope, etc. Channel improvements and cut-offs, training walls and levees, operation of dams and other modifications of natural conditions appreciably affect the stream velocity. Influent rivers in flood tend to elevate the main river waters at the point of confluence according to the magnitude of the flood, thus tending to reduce the main river slope above and to increase it below the confluence point. Accordingly, correlations between river stages and surface velocities at gaging stations cannot be interpreted as applicable to all points along the adjacent river sections, but only serve as general indications.

b. Surface Velocities.

(1) Insufficient basic information concerning stream hydraulic functions (cross-sectional area, wetted perimeter, slope of water surface, roughness factor) is available to permit accurate determination of stream velocities. Estimates were based upon velocities observed during discharge measurements at gaging stations and recorded in Reference 12. Velocities so obtained are not necessarily indicative of the adjacent stream reaches for reasons discussed in paragraph 3-06a, and probably tend to be higher than that for the adjacent stream reaches because discharge measurements are normally made at locations of restricted sections in order to facilitate measurement. The deduced mean velocities were multiplied by 1.18 (i.e. 1/0.85) to obtain corresponding surface velocities. A tabulation of estimated surface velocities at key locations follows:

Station	River km	Estimated Mean - Surface Velocity (km/hr)			
		HHW	MHW	MW	MNW
Rheda	360	-	3.5	2.0	1.5
Greven	295	2.8	2.7	2.5	2.3
Rheine (in gorge)	250	4.8	4.5	2.5	0.8
Hanekenfaehr	214	-	3.0	1.7	-

(2) In order to give an indication of the relative frequency of velocities of various magnitudes, the surface velocities corresponding approximately to various stages of key gaging stations

along the Ems River are shown on the stage duration curves of Plate 12 opposite the corresponding gage heights.

e. Flood Wave Travel Time. Examination of available flood crest times as indicated by noon-day readings recorded in the official German Hydrological Yearbook, References 11 and 12, for the floods of November 1890, November 1926, November 1930, February 1937, and January 1938, indicates an average rate of progression of cresting time of natural floods as follows:

Reach	River km	Average Peak Travel Rate (km/hr)
Greven-Rheine	295-250	1.9
Rheine-Hanekenfaehr	250-214	1.4
Hanekenfaehr-Versen	214-168	1.2

SECTION IV

ARTIFICIAL FLOODING POTENTIALITIES

4-01 GENERAL

a. The term "artificial flood" as used in this report applies to any major increase in the extent of flooding, over that normally prevailing with existing developments, that is brought about by manipulation of control structures, breaching of dams or levees, or temporary damming operations designed to create flooding conditions. Applications of artificial flooding considered in this report fall into the following four general categories:

(1) Still-water barriers, created by flooding land to form water obstacles, using such means as breaching levees, diverting flow from canals, raising crests of existing dams or constructing temporary dams.

(2) Drainage obstacles or mud-flats, in which the wetness of the soil is increased to form muddy or marshy conditions that would impede military traffic, brought about by disrupting the normal drainage of land, destroying pumping and drainage facilities used to drain marshy or low land, or by inducing shallow inundation of flood plains or reclaimed land. Mudflats may also be formed by draining areas normally inundated by reservoirs or ponds.

(3) Streamflow variations, in which changes in discharges, depths, velocities and widths of streams are brought about to hinder stream-crossing operations or navigation such as might be accomplished by opening and closing outlet works of water control structures.

(4) Major flood waves, created by sudden breaching of a dam to release large quantities of impounded water.

b. Many opportunities exist for effective use of "still-wate barriers" and "drainage obstacles" in certain areas of the Ems River basin. The possibilities of such flooding is reviewed in the following paragraphs. Opportunities also exist for effective use of "stream flow variation" and "major flood waves" and should be fully considered in the planning of military operations. This report deals principally with creation of "still water barriers" and "drainage obstacles" along the course of the Ems River; however, certain qualitative evaluation of the possibilities of utilization of "stream flow variation" and "major flood waves" is included.

c. A considerable amount of information regarding artificial flooding possibilities in the Ems River basin is contained in the study

made for the German General Staff, a translation of which is included as Exhibit B of this report, and which has been utilized in preparation of the analyses of artificial flooding potentialities, reviewed in the following paragraphs. Examination of various other documents in connection with preparation of this report disclosed evidence that some studies had been made by Dutch, American, and British sources; however, those references were not available at the time of writing of this report, but are listed in the Bibliography as References 13 to 15, inclusive.

4-02 STILL-WATER BARRIERS AND DRAINAGE OBSTACLES.

a. General. The studies reviewed in this paragraph pertain to the artificial flooding effects that might be produced by creation of still-water barriers and drainage obstacles along the Ems River. The studies were largely based upon a map study of the area, utilizing the 1:25,000 GSGS 4414 map series supplemented by data from References 1 and 3. Exact determination of elevations, contour lines, and flooding boundaries from those maps was difficult; however, the results contained in this report are believed to offer a good indication of the relative possibilities of such flooding. First-hand information should be obtained by local reconnaissance regarding the location and dimensions of levees, roadfills, and culverts and the ground elevations in the vicinity of specific locations in order to accurately establish the area subject to artificial flooding.

b. Hydrologic Considerations. The effectiveness of artificial flooding is contingent in large measure upon the natural hydrologic conditions prevailing at the time of the operation. The amount of water stored and available within the basin, the stage and rate of flow in the streams, are all important factors. Reference is made to Section III of this report for detailed description and to following sub-paragraphs for summarization of those pertinent hydrologic considerations.

(1) The mean discharge of the Ems River during the period 1926 to 1935 ranged from 18.5 m^3/s at Greven (km 295) to 68 m^3/s at Versen (km 168), averaging about 30 m^3/s for the reaches of primary interest. During the dry summer months the average minimum flow would be as low as 3 m^3/s. Flood flows as high as 460 m^3/s have been recorded at Rheine (km 250). Reference is made to Table 5 for additional discharge data.

(2) The natural water supply of the Ems River basin is obtained from rainfall over the drainage areas and supplemented by water supplied to the canals from sources outside of the Ems drainage area. In order to conserve the limited supply, "thrift basins" and repumping of lockage discharge to the higher levels is resorted to at many of the locks. Water is withdrawn from the canal system for water supply of the city of Muenster and for other uses at an average rate of approximately 0.3 m^3/s. The water in the canal system can be

replenished by pumping of water from the following external sources:

Source	Pump Capacity m^3/s
Lippe River	20
Rhine River	13
Weser River	10

However, during periods of extended drought, only the water supplied from the Rhine River can be counted upon as certain. Detailed description of the canal water supply is contained in References 1, 2, and 3.

(3) There are no large reservoirs for water storage in the Ems Basin. Approximately 30 million m^3 of water are contained within the channels of the Dortmund-Ems Canal and other canals of the basin, and could be utilized for flooding purposes at the expense of reduction of navigation and of the inherent water obstacle value of the canals themselves. Within the tidewater sections of the basin, an inexhaustible source of supply is available from the tidal reaches of the Ems River, subject to limitations of tidal variations.

c. Means of Creating Still-water Barriers and Drainage Obstacles.

(1) The water obstacle afforded by the existing waterways of the Ems River basin could be increased by utilization of one or more of the following means:

(a) Creation of still-water barriers by raising crests of existing dams or by construction of temporary dams at suitable sites, combined with confining of the flooding within desired limits by closing of culverts and other outlets in levees and road fills.

(b) Inundation of lowlands by breaching dikes and levees to create still-water barriers or to reduce cross country trafficability.

(c) Inundation of lowlands and formation of drainage obstacles by closing of drainage outlets or removal of pumping facilities.

(d) Inundation of reclaimed tidal lowlands by operation of tide gates to admit water at high tide or to prevent its drainage during low tide.

(2) Analysis was made of the flooding resulting from temporary damming to 1 m and to 3 m above mean water (MW) stages, designated respectively as "low barriers" and "high barriers." The effects of damming to other elevations can be evaluated by comparison

with the effects of the barrier heights studied. For purpose of this study, it was assumed that the temporary damming operations were conducted during mean water conditions and that backwater pools above the structure would have level water surfaces. During high water conditions, greater flooding would be expected due to the increased water surface slope upstream from the temporary dams.

d. Effects of Still-water Barriers in Non-Tidal Reaches.

(1) General. The effects of artificial flooding created by temporary damming operations along the non-tidal reaches of the Ems River are summarized in Table 6, and the extent of the resulting inundation is indicated on the strip maps presented as Plate 15. Serial numbers of sites correspond to the bridge serial numbers of Exhibit A. It may be observed that the flooding induced by the low barriers is minor and is mainly confined to increasing depth in the channel and to flooding of old meander loops of the river. The high barriers create larger water obstacles from 0.5 to 1.5 km wide. However, in neither case is it practical to form a continuous still-water barrier except during natural flood periods. Review of the possibilities of artificial flooding in various reaches of the river follows.

(2) Source to Greven (km 295). Adequate maps were not available to permit detailed analyses of the extreme upper reaches of the river above Marienfeld (km 370). The steep river gradients prevailing in the upper reaches of the river (see profile on Plate 4), together with the height of banks (1-3 m), intensify the difficulty of creating effective still-water barriers. Blocking of bridge openings at the 7 sites indicated on Plate 15, would create short isolated shallow still-water barriers of an average width of about 500 m and length of about 1 km in the case of low barriers, and a width of about 700 m, and length of 2 to 4 km for the high barriers (see Table 6). In this section of the river, breaching of the summer levees and destruction of drainage facilities during periods of above normal river stages would create boggy conditions in the low-lying pastures and hayfields immediately adjacent to the river.

(3) Greven to Rheine (km 251). The bank heights in this reach vary from 2.5 to 4.5 m, necessitating high barriers in order to create appreciable flooding. Damming to lower elevations would create some inundation along the numerous old river meanders. Three suitable sites (Serial Nos. 59, 60, and 63) shown on Plate 15 could be used, in the region of gentler gradient upstream from Rheine, to effect flooding to average depths of about 1 m, widths of 250-400 m, and lengths of 1-10 km.

(4) Rheine to Meppen (km 176). The river flows through a narrow gorge 5-10 m deep, in the section between Rheine and Bentlage

4-02d

Weir (km 246). Bank elevations from 4.5-7.5 m above mean water stage prevail as far downstream as Salzbergen (km 240). Artificial flooding in those reaches would not be practicable. From Salzbergen to Listrup (km 226) banks up to 10 m high are found, and any artificial flooding would be confined to the beds of old meanders. Downstream of Listrup, the flood plain lies 2-3 m above MW. Some shallow artificial inundation to width of 1-2 km, mostly confined to the land adjacent to the old meanders, could be effected by creation of high barriers along that reach. Locations of suitable sites are shown on Plate 15 and information on extent of inundation is contained in Table 6.

(5) Meppen to Herbrum (km 107). The river flows through a 1.5-3 km wide valley lying approximately 2 m above the river bed, subject to flooding by winter floods but not normally covered by summer floods. In the lower part of this reach, erection of high barriers would create water obstacles with average depths of 0.5 to 0.75 m, widths of 2-4 km, and lengths of 4-17 km as shown in Table 6 and on Plate 15. In addition, as described in Exhibit B, inundation of adjacent low-lying depressions, east of the canalised river can be effected by diversion of water from the upper pools of the locks and dams at Huental (Voerssen) (km 168), Duethe (km 142), and Herbrum (km 107), through the irrigation outlets provided at those locations.

(6) Water Requirements for Still-Water Barriers. The total water required to effect the artificial flooding described in previous paragraphs and indicated in Table 6 and Plate 15 would be approximately 5 million m^3 for the low barriers or 80 million m^3 for the high barriers. At the average natural flow of 30 m^3/s expected during mean water conditions, complete filling of all the indicated flooded areas would take about 2 days for the low barriers or 31 days for the high barriers. Following are tabulated water requirements and estimated filling times for various reaches:

Reach	Water Requirement (million m^3) Low Barrier	High Barrier	Filling Time at 30 m^3s (days-hrs.) Low Barrier	High Barrier
Source-Greven	2.4	15.6	0-22	6-0
Greven-Rheine	0.1	7.1	0- 1	2-17
Rheine-Meppen	1.3	17.5	0-12	6-17
Meppen-Herbrum	1.2	40.5	0-11	15-6

Utilisation of the 53 m^3/s supplied from outside sources to the canals of the basin and of the 30 million m^3 water stored in the canal channels (as described in paragraph 4-02b) would reduce the time required for filling, contingent upon the relative locations and elevations of the canal water and the still-water barriers.

(7) Combination of Still-water Barriers with Natural Water Obstacles. From Lingen (km 208) to Papenburg (km 94), the Ems

River is flanked on the east by the Dortmund-Ems Canal and the partly completed Ems-Seitan Canal, and on the west by the Sued-Nord Canal, with many off-shooting drainage ditches interconnected by other canals with the Dutch waterways (see Plates 1 and 2). On both sides of the Ems River, there are many extensive areas of marshes and moors. Together with the river, these present a considerable cumulative obstacle, the effectiveness of which might be increased by proper combination with still-water barriers at suitable sites as indicated in preceding paragraphs.

e. Artificial Flooding Potentialities in Tidal Reaches. In the tidal reaches of the Ems River below Herbrum (km 107), it is possible to inundate the extensive reclaimed tidal marsh regions to various depths by breaching of levees and dikes, operation of tide gates, and closing of normal drainage outlets and facilities. The possible extent of such inundation is indicated on the General Map, Plate 1. The entire area is intersected by drainage ditches and dikes and lies generally below the elevation of high tide. During low tide, much of the area would be uncovered, but due to poor drainage would probably be water soaked. Detailed analysis was not made of the flooding possibilities in this region due to lack of adequate data as to elevations of the land and the elevation and location of the dike and drainage system. Reference is made to Exhibit B and to References 1, 3 and 4 for additional information.

f. Artificial Flooding Potentialities of the Dortmund-Ems Canal.

(1) The stage in the Dortmund-Ems canal could not be raised appreciably, the maximum limit being approximately the level of the top of the lock gates. Certain possibilities exist for inundation of adjacent low-lying areas in the immediate vicinity of the canal by breaching of the canal banks at crossings of streams and in reaches where the leve of the canal water surface is higher than the surrounding ground. Possible locations for such operations exist along the portions of the canal indicated as being within embankments on the Location Plan, Plate 2. The overland inundation resulting from such diversion of water would be of relatively short duration, limited by the storage available within the canal and by the rate of runoff of the water from the land into the river through natural drainage channels. Quantative evaluation of the possible effect has not been attempted in this report due to limitations of essential basic data.

(2) In the event that the navigation use and the water obstacle afforded by the Dortmund-Ems and Ems-Weser canal become non-critical, it might be desirable to utilize the water stored in the canals to create artificial flooding along other streams of the basin and to forestall detrimental utilization by the enemy. Breaching of the canal aqueduct at the Ems River and the Glane River crossings (sites of RAF bombing during the war) would empty approximately 13 million m^3

into those rivers, provided the canal safety gates and locks along the canal were opened (See plates 1, 2, 7 and 10). The rate of outflow, however, would be too slow to produce an effective flood wave. Approximately 5 million m^3 could be discharged at the Ems River crossing and 3 million m^3 at the Glane River crossing in a 48 hour period, and several weeks would be required to completely drain the canal. The estimated rates of discharge resulting from breaching of the canal aqueducts at the Ems River and Glane River crossings follow:

Hours after Breaching	Rate of Discharge (m^3/s) Ems River	Glane River
1	100	100
3	65	65
6	50	45
12	35	20
24	25	5
48	15	1

g. Artificial Flooding Potentialities of the Canals west of the Ems River. The canal system west of the Ems River, including the Sued-Nord and Ems-Vechte Canals and the Lee and Vechte Rivers afford certain potentialities for artificial flooding. Locations of those canals are shown on Plate 1, profiles are presented on Plates 8 and 9, and descriptions are contained in paragraph 2-12 and in Exhibit B. Combination of flow diversion between the interconnected waterways of the system, coupled with breaching of canal embankments and opening of outlets would inundate an extensive area along the Vechte and Lee Rivers northwest of Nordhorn as indicated on the General Map, Plate 1 and discussed in Exhibit B.

4-03 MAJOR FLOOD WAVES.

a. No large storage dams exist in the Ems River basin, thus eliminating the possibility of creating major flood waves by breaching such dams.

b. Flood waves 1 to 2 m in height and of about 12 hours duration could be created by sudden destruction of navigation locks and dams on the Ems River and Dortmund-Ems Canal. Reference is made to Exhibit B for detailed description of the effect at specific locations. Locations of dams are shown on Plates 1, 2, 4, 5, 6, and 7. Successive progressive destruction of dams could intensify and prolong the effective waves.

4-04 STREAM FLOW VARIATION.

The depth and velocity of flow in the Ems River could be increased or decreased by manipulation of the controlled outlets of the navigation dams, locations of which are shown on Plates 1, 2, 4, 5,

6, and 7. The limited storage capacity and water supply, discussed in paragraph 4-02b would hinder the replenishment of released water and thus limit utilization of cyclic flow variation. Detailed analysis of the effect of stream flow variation was not made in this study due to the lack of essential data. Reference is made to Exhibit B for description of the effects of operation of the locks and dams upon flows in the waterways of the basin.

4-05 SUMMARY.

The artificial flooding potentialities of the Ems River Basin discussed in preceding paragraphs 4-01 to 4-04 are herein summarized.

a. By means of temporary damming operations at suitable existing damsites and bridge openings, as shown on Plate 15 and in Table 6, it would be possible to create inundation extending upstream from those barriers for 1 to 17 km and 0.5-4 km wide. The average depth of overbank flooding would be from 0.5 to 1 m. Except during high water periods, the resulting overbank flooding would not present a continuous water obstacle. Temporary dams with heights of less than 3 m above mean water would not cause appreciable overbank flooding. Detailed discussion appears in paragraph 4-02d.

b. Breaching of levees and manipulation of drainage outlets would permit inundation of the low-lying reclaimed areas in the tidal reaches of the river, as shown on Plate 1 and discussed in paragraph 4-02e.

c. Shallow inundation of isolated low-lying areas could be accomplished by diversion of water from the navigation canals within the basin (See Plate 2 and paragraph 4-02f).

d. Total destruction of the navigation dams on the waterways of the basin would create flood waves 1 to 2 m high and of approximately 12 hours duration (See paragraph 4-03 and Exhibit B).

e. Manipulation of the control outlets of the navigation structures along the Ems River would produce slight variation in depth and velocity of flow, as discussed in paragraph 4-04 and Exhibit B.

f. The inadequate water supply of the Ems basin during periods of drought would limit the artificial flooding possibilities. Detailed discussion is contained in paragraph 4-02d(6).

SECTION V

EFFECT ON MILITARY OPERATIONS

5-01 GENERAL.

The purpose of this section is to assist military planning personnel in estimating the relative value and effect of artificial floods on associated military operations such as: bridging and ferrying, trafficability, and tactical and logistical factors. The effects of artificial floods on military operations may vary greatly, depending upon the type of equipment involved, the tactical situation, and hydrologic conditions. The effects presented in this section are opinions based largely on discussions of the military effects of artificial floods given in Exhibit B, a military geography document published by the German Army.

5-02 EFFECT OF STILL-WATER BARRIERS AND DRAINAGE OBSTACLES.

a. Reference is made to paragraph 4-02 for discussion of the hydraulic features associated with formation and augmentation of water obstacles by means of temporary damming and disruption of normal drainage.

b. Bridging and ferrying operations within the backwater reaches above the temporary dams would be hindered by reason of the resulting greater width and depth of crossing. Approach trafficability would be decreased by the shallow overbank flooding, and increased stream depths would hinder possible fording of the upper reaches of the river. The non-continuous nature of the resulting increased water obstacle (as illustrated on Plate 15) could be compensated by planning its use in combination with other natural obstacles and with tactical operations to channelize or restrict military action. The importance of the resulting reduction of velocity within the backwater reaches is minimized by the low normal natural stream velocities shown in paragraph 3-06b.

c. Continuous military support of the temporary dam installations would be necessary to prevent their destruction by enemy ground or air action. Destruction of a temporary dam would release a flood wave that would hinder crossing operations downstream from the structure for a short period and which might cause progressive failure of other downstream dams.

d. Maneuverability and trafficability over an extensive area as shown on Plate 1, would be greatly hindered by inundation of the reclaimed marshland adjacent to the tidal reaches of the Ems River below Herbrum (km 107) by admission of salt water through the dikes and by disruption of the normal drainage.

c. Maximum effectiveness of still-water barriers and drainage obstacles would be attained by combination of artificial flooding with other natural obstacles such as the numerous marshy areas and canals. The careful selection of the most advantageous flooding locations is imperative in order to get the maximum benefit from the limited supply of water normally available for flooding purposes (See Plates 1, 3 and 15).

5-03 EFFECT OF MAJOR FLOOD WAVES.

a. Reference is made to paragraph 4-03 and Exhibit B for discussion of the hydraulic features associated with creation of major flood waves by means of destruction of existing locks and dams along the Ems River and Dortmund-Ems Canal.

b. Destruction of the navigation structures would create flood waves of up to 12 hours duration, and heights of 1 to 2 m, that would disrupt navigation, eliminate power supply of mills and industries, possibly damage or destroy downstream dams, create some local inundation, interfere with stream crossing operations and endanger floating equipage and floating bridges in the sections of the stream downstream from the destroyed installation. Reference is made to Exhibit B for detailed description of the resulting damages that might be incurred by destruction of specific dams, and to Plates 1, 2, 4, 5, 6 and 7 for locations of structures.

5-04 EFFECT OF STREAM FLOW VARIATION.

a. Reference is made to paragraph 4-04 and Exhibit B for discussion of the hydraulic effects associated with stream flow variation by means of manipulation of the discharge control outlets of the navigation dams on the Ems River and Dortmund-Ems Canal, locations of which appear on Plates 1, 2, 4, 5, 6 and 7.

b. Detrimental stream flow variation would result from opening and closing of the movable gates and other controlled outlets of the navigation dams. Sudden opening would disrupt navigation by increasing stages downstream and decreasing stages upstream from the dam, disrupt power supply of mills and industries, create moderately large waves that would cause some local inundation, endanger downstream dam structures, interfere with stream crossing operations and endanger floating equipage downstream from the sudden discharge. Sudden closing would have less effect upon navigation and power, but would hinder military crossing operation by the associated lowering of downstream stages, and raising of upstream stages. Manipulation of the control gates to create artificial cyclic oscillating waves would increase the value of the stream as a military obstacle by the action upon military floating bridging and ferrying operations. The limited water storage capacity of the dams and the limited supply of water for replenishment of the depleted storage would limit the extent and frequency of cyclic variations.

Reference is made to Exhibit B for detailed description of the effects of opening and closing of the outlet controls of specific dams.

c. Deliberate destruction of upstream navigation or mill dams or their control gates would insure against their utilization by the enemy to produce flood waves or detrimental flow variations to interfere with military operations at a later critical period.

5-05 EFFECTS RELATED TO OTHER RIVER BASINS.

Creation of artificial flooding in the Ems River Basin could be coordinated with similar operations on other river basins to create simultaneous or progressive water obstacles. Reference is made to reports of artificial flooding possibilities on the Rhine River, Danube River, Weser River, and Aller and Leine Rivers listed as References 16 to 20, inclusive, in the Bibliography of this report.

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TABLES

TABLE I
EQUIVALENT ENGLISH-METRIC TERMS

To reduce A to B, multiply A by F. To reduce B to A, multiply B by G.

Unit A	Factor F	Factor G	Unit B
Miles	1.60935	.62137	Kilometers
Meters	3.2808	.30480	Feet
"	39.370	.025400	Inches
Square Miles	2.590	.3861	Square Kilometers
" "	259.000	.0038610	Hectares
Hectares	2.47104	.40469	Acres
Acres	4046.9	.00024710	Square Meters
Cubic Meters	35.3145	.028317	Cubic Feet
Cubic Feet	28.317	.035314	Liters
Acre-feet	43560.	.000022957	Cubic Feet
"	1233.5	.00081071	Cubic Meters
Cubic Feet per second	1.9835	.50417	Acre-feet per 24 hours
" Meters per "	35.3145	.028317	Cubic-feet per second
Miles per hour	1.60935	.62137	Kilometers per hour
" " "	1.4667	.68182	Feet per second
Meters per second	3.2808	.30480	" " "
" " "	2.2369	.44704	Miles per hour
Feet per second	1.097	.99113	Kilometers per hour
Tons (metric)	1.102	.9072	Tons (short)
" (long)	1.016	.9842	" (metric)
" (metric)	2205.	.0004536	Pounds (avoirdupois)
" (metric)	1000.	.001	Kilograms

TABLE 2
HYDROLOGIC TERMS AND ABBREVIATIONS
(In conformance with German practice)

Non-Tidal Stage	High-Tide Stage	Low-Tide Stage	Rate of Discharge (m^3/sec)	Discharge per Unit area (1/sec-km^2)	Definition
HHW	HHThw	HHTnw	HHQ	HHq	Highest value ever known or observed
HW	HThw	HTnw	HQ	Hq	Highest value observed during a stated period of time
MHW	MHThw	MHTnw	MHQ	MHq	The mean high value during a stated period, derived by averaging the highest values of each unit time element (i.e. MHW 1926/35 is average of the 10 yearly peak stages)
MW	MThw	MTnw	MQ	Mq	The mean (arithmetical average) of all observations during a stated time period
MNW	MNThw	MNTnw	MNQ	MNq	The mean low value during a stated period, derived by averaging the lowest values of each unit time element (MNW 1926/35 is the average of the 10 yearly lowest stages)
NW	NThw	NTnw	NQ	Nq	Lowest value observed during a stated period of time
NNW	NNThw	NNTnw	NNQ	NNq	Lowest value ever known or observed

Table 2

TABLE 3
SUMMARY OF GAGE DATA - EMS RIVER (Non-tidal Reaches)

Main Source: Jahrbuch fuer die Gewaesser Kunde des Deutschen Reichs, Abflussjahr 1938

Gage	GSGS Map Series 4416 4414	"Nord du Guerre" Grid	Km. Above Mouth of Ems River	Drainage Area Sq. Km.	Gage Zero m/NN	Item*	Date or Period of Record	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Year
Greven	F2/3911	A9188	295.2	2898	32.72	HHW	Nov 1890													797
						HW	1926-35													744
						MHW	"	451	468	578	478	433	463	354	273	266	221	196	333	638
						MW	"	304	322	395	360	293	305	207	168	158	140	139	197	248
						MNW	"	191	214	242	250	200	203	135	111	99	100	99	119	89
						NW	"													62
						NNW	Aug 1921													60
Rheine (Lower Lock)	M2/3710	V7910	250.5	3740	24.18	HHW	Nov 1890													820
						HW	1926-35													759
						MHW	"	387	382	476	380	332	353	282	226	231	205	192	270	551
						MW	"	265	271	323	295	246	256	199	175	169	161	159	194	226
						MNW	"	191	203	225	221	191	193	157	142	136	133	134	148	126
						NW	"													106
						NNW	Sept 1919													82
Versen (upstream of weir)	M1/3209	V6759	168.4	8404	6.69	HHW	June 1926													516
						HW	1926-35													516
						MHW	"	294	331	387	325	293	304	267	196	191	164	159	232	428
						MW	"	211	228	264	254	209	213	162	138	125	120	120	154	182
						MNW	"	152	154	196	190	149	146	112	103	95	94	99	107	89
						NW	July 1930													80
						NNW	July 1930													80
Papenburg	M2/2810	Q7501	93.8		-5.00	HHThw	Jan 1901													846
						HThw	1926-35													819
						MHThw	"													782
						MThw	"	643	637	653	636	632	642	638	639	644	639	639	650	641
						MNThw	"													502
						NThw	"													457
						NNThw	Jan 1922													439
						HHTnw	Jan 1926													757
						HTnw	1926-35													757
						MHTnw	"													642
						MTnw	"	489	495	534	500	477	479	461	457	459	456	458	475	478
						MNTnw	"													388
						NTnw	"													350
						NNTnw	Oct 1908													339

*See Table 2 for definition of symbols

TABLE 4
SUMMARY OF GAGE DATA - EMS RIVER (Tidal Reaches)

Main Source: Jahrbuch fuer die Gewaesser Kunde des Deutschen Reichs, Abflussjahr 1938

Gage	GSGS Map Series 4416	"Nord de Guerre" Grid	Km. Above Mouth of Ems River	Drainage Area Sq. km.	Gage Zero m/NN	Item*	Date or Period of Record	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Jul	Aug.	Sept.	Oct.	Year
Leerort	32 / 2710	Q7913	77.0		-5.00	HHThw	Mar 1906													1004
						HThw	1931-35													884
						MHThw	"													818
						MThw	"	641	630	644	646	626	639	637	640	650	643	646	656	642
						MNThw	"													498
						NThw	"													461
						NNThw	Nov 1916													386
						HHTnw	Oct 1926													676
						HTnw	1931-35													646
						MHTnw	"													590
						MTnw	"	407	399	417	415	389	398	388	386	396	391	398	412	400
						MNTnw	"													312
						NTnw	"													290
						NNTnw	Nov 1916													210
[illegible] (New Lock)	12 / 2609	Q6327	50.8		-5.00	HHThw	Mar 1926													1018
						HThw	1926-35													903
						MHThw	"													677
						MThw	"	629	621	628	618	615	624	624	630	636	632	631	641	628
						MNThw	"													479
						NThw	"													429
						NNThw	Jan 1905													367
						HHTnw	Dec 1894													769
						HTnw	1926-35													649
						MHTnw	"													573
						MTnw	"	335	329	330	319	313	317	313	322	328	345	336	350	337
						MNTnw	"													203
						NTnw	"													169
						NNTnw	Jan 1937													141

*See Table 2 for definition of symbols

TABLE 5

DISCHARGE DATA - EMS RIVER

Period 1926-35

Gage	Greven	Rheine	Versen
Km, above Mouth	295	250	168
Drainage Area: (Km^2)	2695	3740	8404
Discharge (m^3/s) / Discharge/unit area ($l/s/km^2$)			
HHQ / HHq	580* / 200	460(2) / 123	370* / 44.1
	26 Nov. 1890	27 Nov. 1890	6 Jan 1926
HQ / Hq	320* / 110.5	358(2) / 95.7	370* / 44.1
MHQ / MHq	116(1) / 40.0	195(2) / 52.1; 188(1) / 50.3	230(1) / 27.4
MQ / Mq	18.5(1) / 6.38	32.3(2) / 8.64; 27.8(1) / 7.43	68.0(1) / 8.10
MNQ / MNq	2.40(1) / 0.83	5.07(2) / 1.36; 4.20(1) / 1.12	—
NQ / Nq	—	3.14(2) / 0.84	—
NNQ / NNq	—	—	—

(1) Flow at MHW, MW, MNW from Jahrbuch fuer die Gewässerkunde des Deutschen Reichs - 1938.

(2) Mean and extreme discharges (Q) tabulation in 1938 Jahrbuch.

* Flow at mean and extreme stages of tables 3 and 4 obtained by application of discharge rating curves from Plate 14.

TABLE 6
EMS RIVER
INUNDATION EFFECT OF STILLWATER BARRIERS

Serial No.	Km above mouth of Ems	Map GSGS series 4416/4414	"Bord de Guerre" Grid	Location and Description *	Low stillwater barrier (1m/MW) Pond level m/NN	Length km	Aver. width m	Aver. depth m	Pond area km^2	Vol. $10^6 x m^3$	High stillwater barrier (3m/MW) Pond level m/NN	Length km	Aver. width m	Aver. depth m	Pond area km^2	Vol. $10^6 x m^3$
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	392 to 372		Maps of area not available													
79AC	366.3	P2/4015	374701	S. of Marienfeld Rd. Br. 2 span Total opening 24 m Stream width 18 m	65.0	2	500	0.5	1	0.5	66.6	4.5	900	1	4	4.0
					Must hold along 600 m of road embankment. May require blocking of ditch on left bank.											
79Z	365.5	P2/4015	350710	S.W. of Marienfeld Rd. Br. 2 span Total opening 28 m Stream width 18 m	63.0	1.5	500	0.4	0.75	0.3	65.0	5	600	1.1	3	3.3
					Must hold along 800 m of road embankment. May require blocking of drainage ditches under left embankment.											
79[illegible]	363.3	P2/4015	334720	S. of Harsewinkle Rd. Br. 1 span Total opening 15.3 m Stream width 12 m	61.6	1	400	0.4	0.4	0.2	63.6	3	500	1.2	1.5	1.8
79Y	359.4	P2/4015	304735	S.W. of Harsewinkle Rd. Br. 1 span Total opening 22 m Stream width 12.2 m	59.5	3	300	0.5	2.7	1.4	61.5	4.5	900	1.1	4	4.4
					Must hold along 1 km of embankment. May have to block opening under embankment on left bank of river.											
	359 to 346		No significant flooding													
79M	345.6	P2/4013	174730	Warendorf Rd. Br. 3 spans Total opening 30.5 m Stream width 19.5 m	51.4 No significant flooding						53.4	4	500	1	2	2.0
	346 to 327		No significant flooding													
79C	326.9	P2/4012	035763	Telgte Rd. Br. 9 spans Total opening 725 Stream width 10-28 m	45 No significant flooding						47	1	300	0.5	0.3	0.15
											Flooding on left bank only. Requires blocking of bridge on river and bridge on mill channel					
	327 to 271		No significant flooding													

*See Exhibit A for details

TABLE 6
EMS RIVER
INUNDATION EFFECT OF STILLWATER BARRIERS

Serial No.	Km above mouth of Ems	Map 0608 series 4416/4414	"Nord de Guerre" Grid	Location and Description*	Low stillwater barrier (1m/MW) Pond level m/NN	Length km	Aver. width m	Aver. depth m	Pond area km²	Vol. 10⁶x m³	High stillwater barrier (3m/MW) Pond level m/NN	Length km	Aver. width m	Aver. depth m	Pond area km²	Vol. 10⁶x m³
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
63	270.5	P2 / 3811	868957	Emsdetten Rd. Br. 3 spans Total opening 76.8 Stream width 22.5	No significant flooding						34.8	1	250	0.5	0.25	0.12
60	266.3	M2-P2 / 3711	842041	Mesum Rd. Br. 3 spans Total opening 76.6 m Stream width 34.0 m	No significant flooding						34	5	400	1	2	2.0
59	253.4	M2-P2 / 3710	808080	Rheine RR Br. 6 spans Total opening 103 m Stream width 54 m	31.50	2	300	0.2	0.6	0.12	33.5	10	400	1.25	4	5.0
251 to 246				Rheine to Bentlage Weir - River runs in gorge 5-10 m deep. No flooding probable.												
246 to 240				Bentlage to Salzbergen - Banks are 4.5 to 7.5 m high. No flooding probable.												
52	226.0	3610	730220	Listrup Weir	Site not considered suitable. Flooding confined to channel or old meander beds.											
50	214.4	M1 / 3509	711304	Elbergen RR Br. 3 spans Total opening 108 m Stream width 86 m	22.5	4.5	600	0.5	2.7	1.3	24.8	8	1100	1.2	8.8	10.6
49	213.9	M1 / 3509	705306	Hanekenfaehr Weir	22.5 Flooding would cover same area as Elbergen Br., but would require erection of temporary levees on left bank between Weir and Ems-Vechte Canal, approximately 500 m.						24.5					
48	208.3	M1 / 3409	705352	Lingen Rd. Br. 2 spans Total opening 66 m Stream width 56 m	18 No significant flooding.						20 Flooding of old meanders. Requires blocking of 2 bridges over Dortmund-Ems Canal or construction of temporary levee approximately 200 m long between river and canal.					
45	202.0	M1 / 3409	682390	Altenlingen Rd. Br. 5 spans-Total opening 82 m Stream width 43.5 m	16.60 No significant flooding.						18.60 Flooding of old meander beds.					
43	192.3	M1 / 3409	669446	Dalum Rd. Br. 8 spans Total opening 72.3 Stream width 63.3	14.5 No significant flooding.						16.5 Flooding of old meander beds and low ground immediately adjacent to channel.					
41	175.7	M1 / 3309	598555	Meppen Rd. Br. 6 spans Total opening 64 m Stream width 60.2	11.4 No significant flooding.						13.4 Must hold along 1 km of RR embankment or flow will be diverted overland and re-enter the river near Versen Weir	6	1400	0.8	8.5	6.9

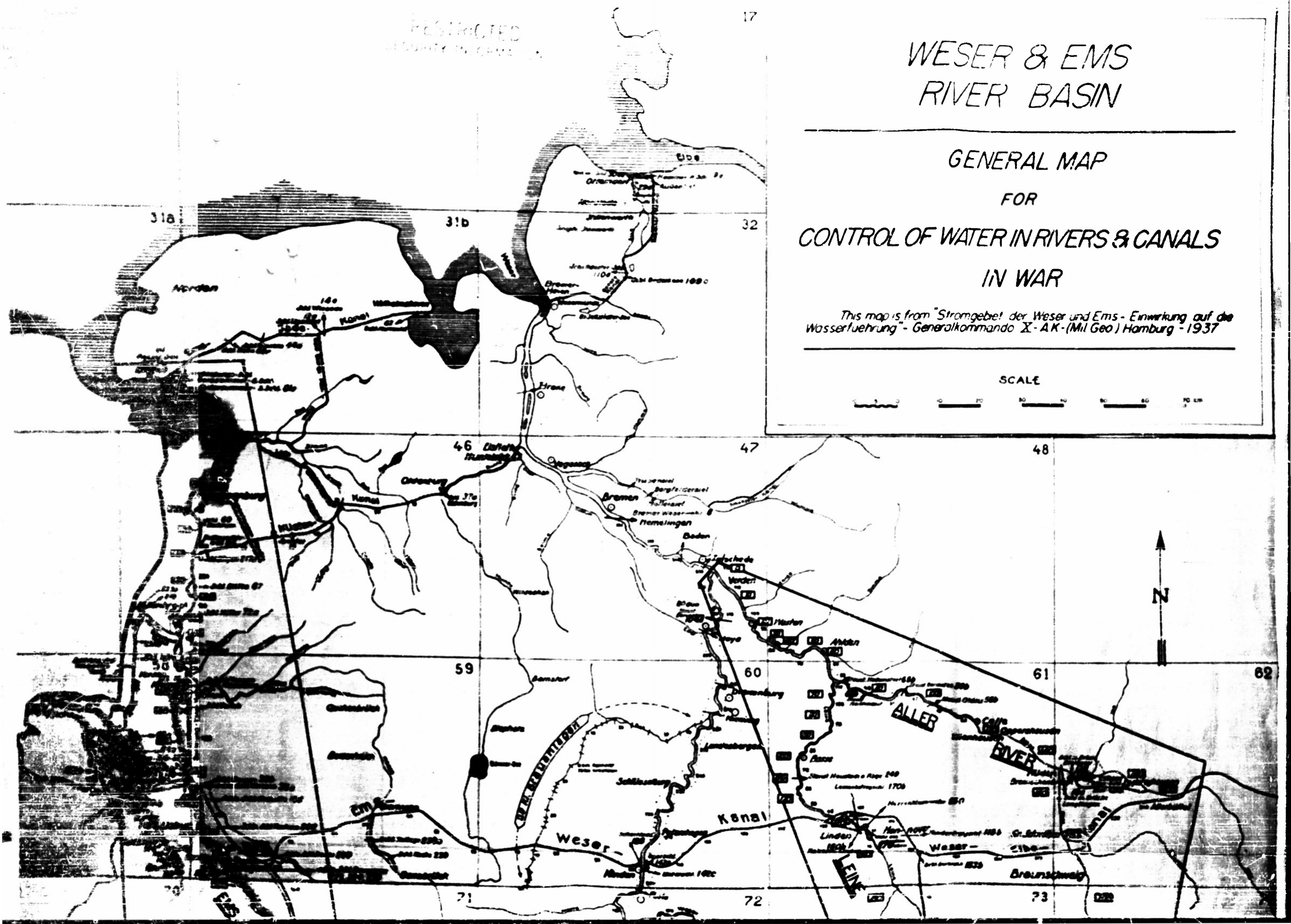
*See Exhibit A for details

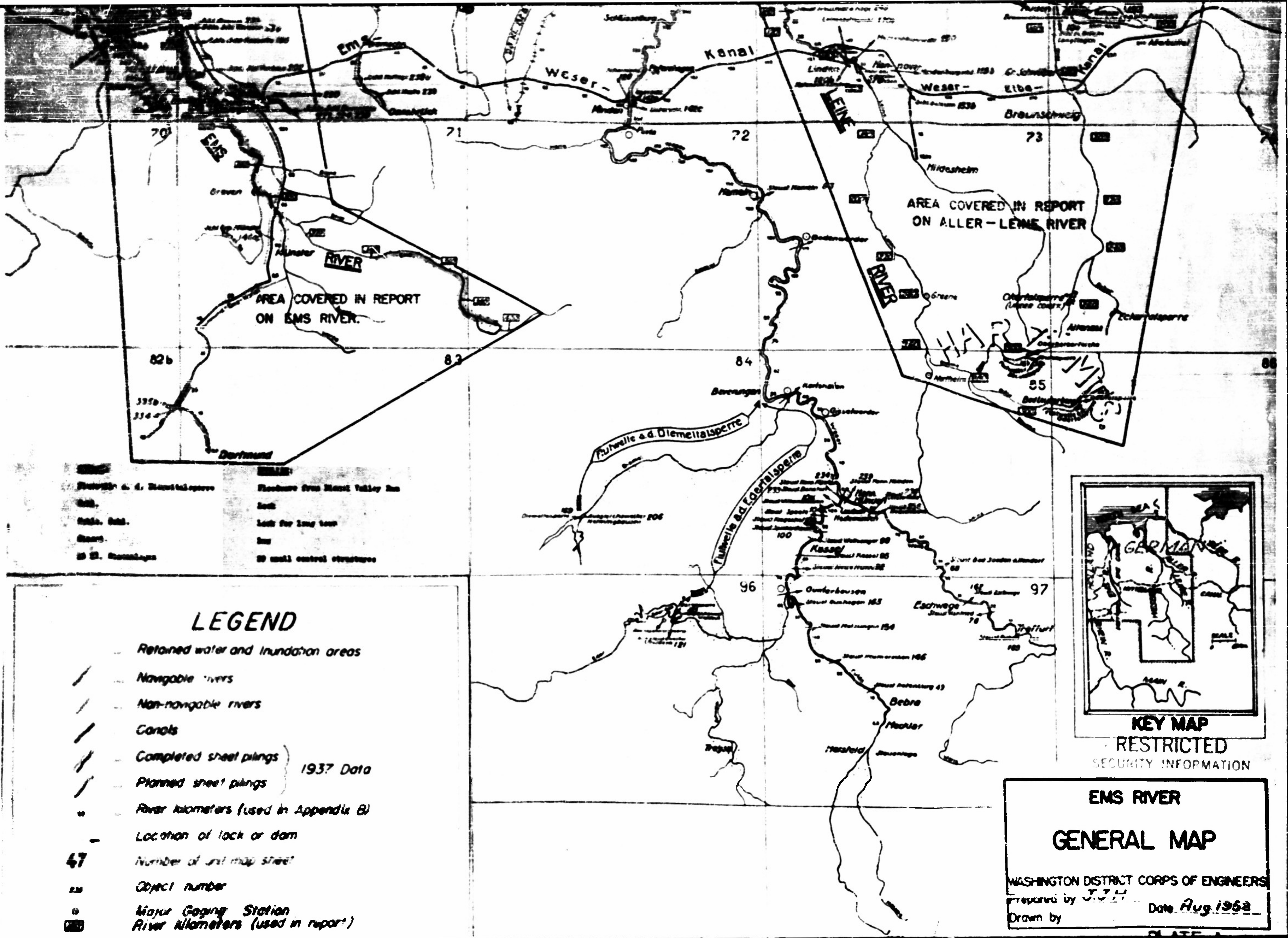
TABLE 6
EMS RIVER
INUNDATION EFFECT OF STILLWATER BARRIERS

Serial No.	Km above mouth of Ems	Map GSGS series 4416 4414	"Nord de Guerre" Grid	Location and Description*	Low stillwater barrier (1m/NN) Pond level m/NN	Length km	Aver. width m	Aver. depth m	Pond area km^2	Vol. $10^6 x$ m^3	High stillwater barrier (3m/NN) Pond level m/NN	Length km	Aver. width m	Aver. depth m	Pond area km^2	Vol. $10^6 x$ m^3
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
39	168.4	N1 3209	672595	Veersen Weir	2 weirs at this point; 1 on meander and 1 on cut-off. Site not considered suitable for flooding.											
34	164.0	M1-N1 3209	662627	Meppen Rd. Br. 4 spans Total opening 110 m Stream width 54 m	c.6 No significant flooding.						10.6 Flooding of old meander beds.					
33	158.6	M1-N1 3209	671662	Haren Rd. Br. 7 spans Total opening 144.5 Stream width 31 m	8.5 No significant flooding.						10.5	4.3	2200	0.75	9.5	7.1
32	151.0	M1 3109	681703	Hilter Weir	Weir bypassed by canal. Low lying plain to left of Weir channel. Site not considered suitable.											
28	143.2	M1 3109	713746	Lathen Rd. Br. 1 main span Total opening 91.9 Stream width 70 m	6.0 No significant flooding.						8.0	6.8	3600	0.6		
27	141.6	M1 3109	716760	Duethe Weir	Low ground to left of weir. Site not considered suitable.											
21	128.0	M1 3009	708812	Steinbild Rd. Br. 2 spans Total opening 125.4 m Stream width 55.4 m	5.0 No significant flooding.						7.0	10	2600	0.5	26	13.0
20	118.4	M1 3009	709875	Heede Rd. Br. 5 spans Total opening 206.8 m Stream width 56.0 m	5.0 Old bed on left bank.	4	600	0.4	2.4	1.0	6.9	17	2400	0.5	40.8	20.4
					5.0 Old bed on right bank.	3	200	0.3	0.6	0.2	Includes area covered by Steinbild High Barrier.					

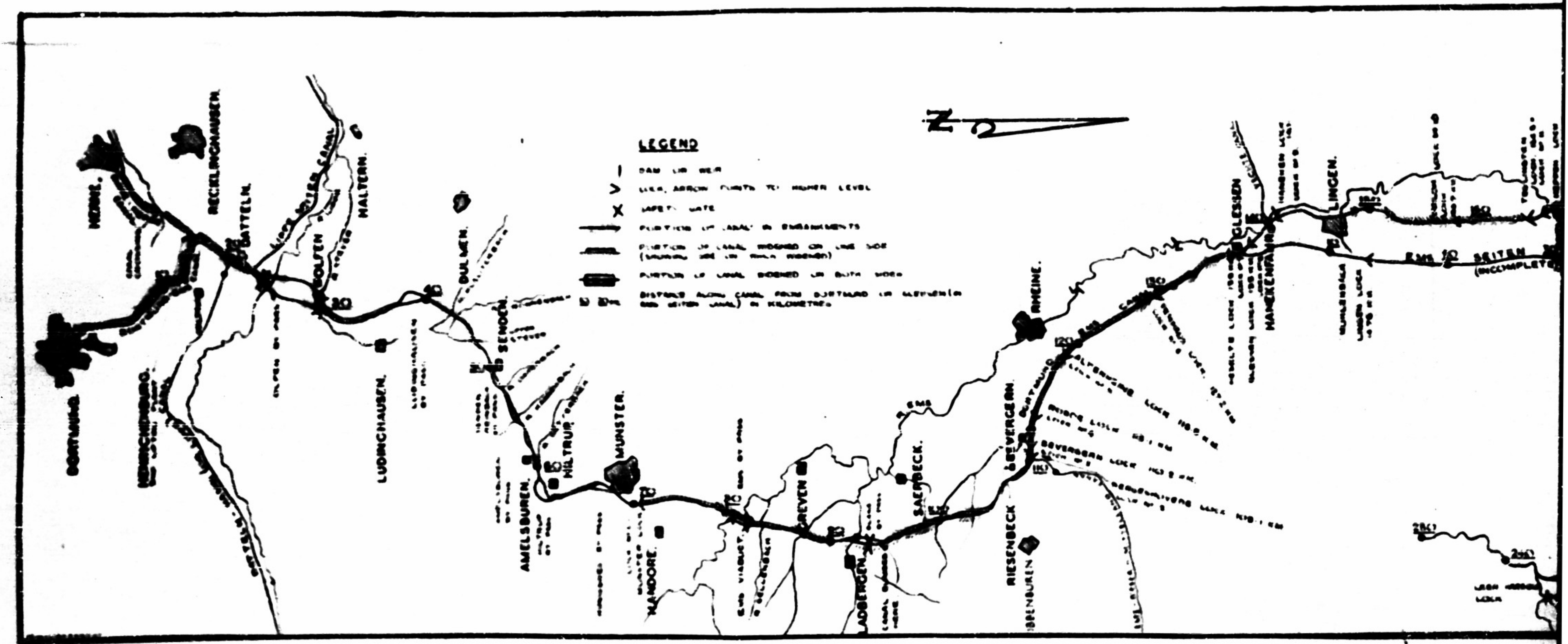
*See Exhibit A for details

PLATES


WESER & EMS
RIVER BASIN
GENERAL MAP
FOR
CONTROL OF WATER IN RIVERS & CANALS
IN WAR
This map is from "Stromgebiet der Weser und Ems - Einwirkung auf die Wasserfuehrung" - Generalkommando X - A.K - (Mil Geo) Hamburg - 1937
SCALE
N
Elbe
Norden
Kanal
Oldenburg
Bremen
Hemelingen
Verden
Ahlden
ALLER
RIVER
LEINE
Kanal
Weser-
Minden
Linden
Weser-
Elbe-
Braunschweig
31a
31b
32
46
47
48
59
60
61
62
71
72
73



Ems
Kanal
Weser-
Weser-
Elbe-
Kanal
Minden
Hannover
Braunschweig
Hildesheim
LEINE
RIVER
EMS
RIVER
Münster
Dortmund
Hameln
Kassel
Bebra
Eschwege
Treffurt
70
71
72
73
82b
83
84
85
96
97
AREA COVERED IN REPORT ON ALLER-LEINE RIVER
AREA COVERED IN REPORT ON EMS RIVER.
Fulwelle a.d. Diemeltalsperre
Fulwelle a.d. Edertalsperre
LEGEND
Retained water and inundation areas
Navigable rivers
Non-navigable rivers
Canals
Completed sheet pilings
Planned sheet pilings
1937 Data
River kilometers (used in Appendix B)
Location of lock or dam
47 Number of unit map sheet
Object number
Major Gaging Station
River kilometers (used in report)
KEY MAP
RESTRICTED
SECURITY INFORMATION
EMS RIVER
GENERAL MAP
WASHINGTON DISTRICT CORPS OF ENGINEERS
Prepared by
Drawn by
Date Aug 1952



REPRODUCED FROM "REPORT ON RIVER EMS," G.S.I. (XB)
MAIN HQ., 21ST ARMY GROUP. DECEMBER, 1945.

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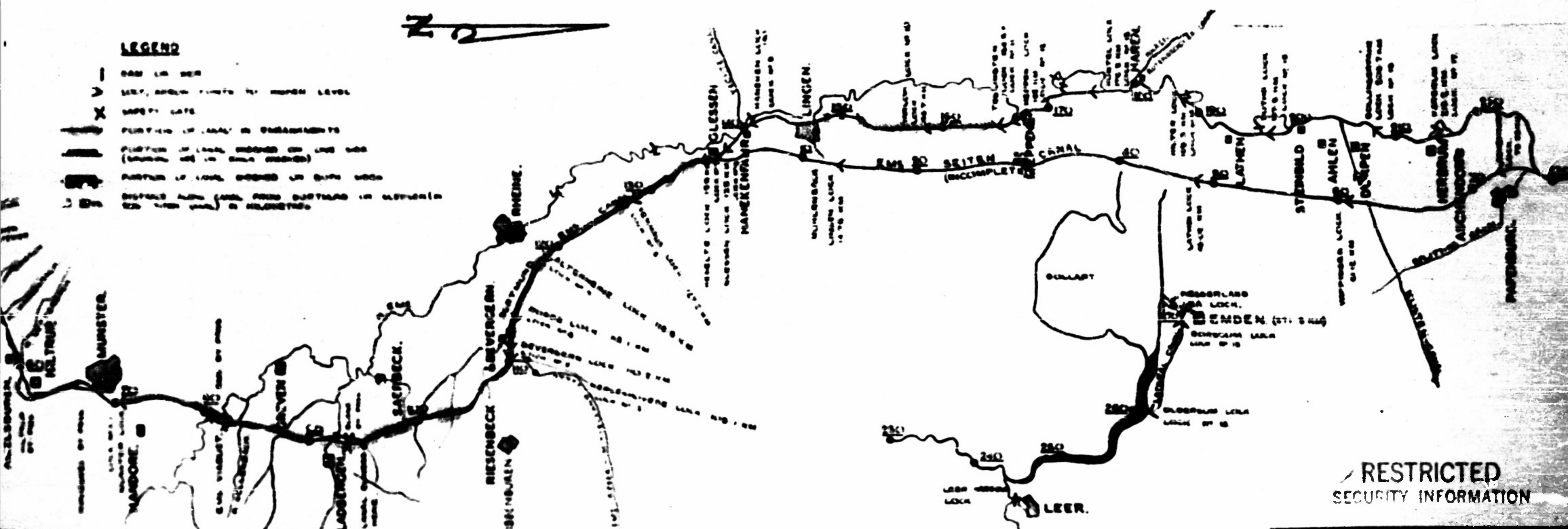
SECURITY INFORMATION



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SECURITY INFORMATION

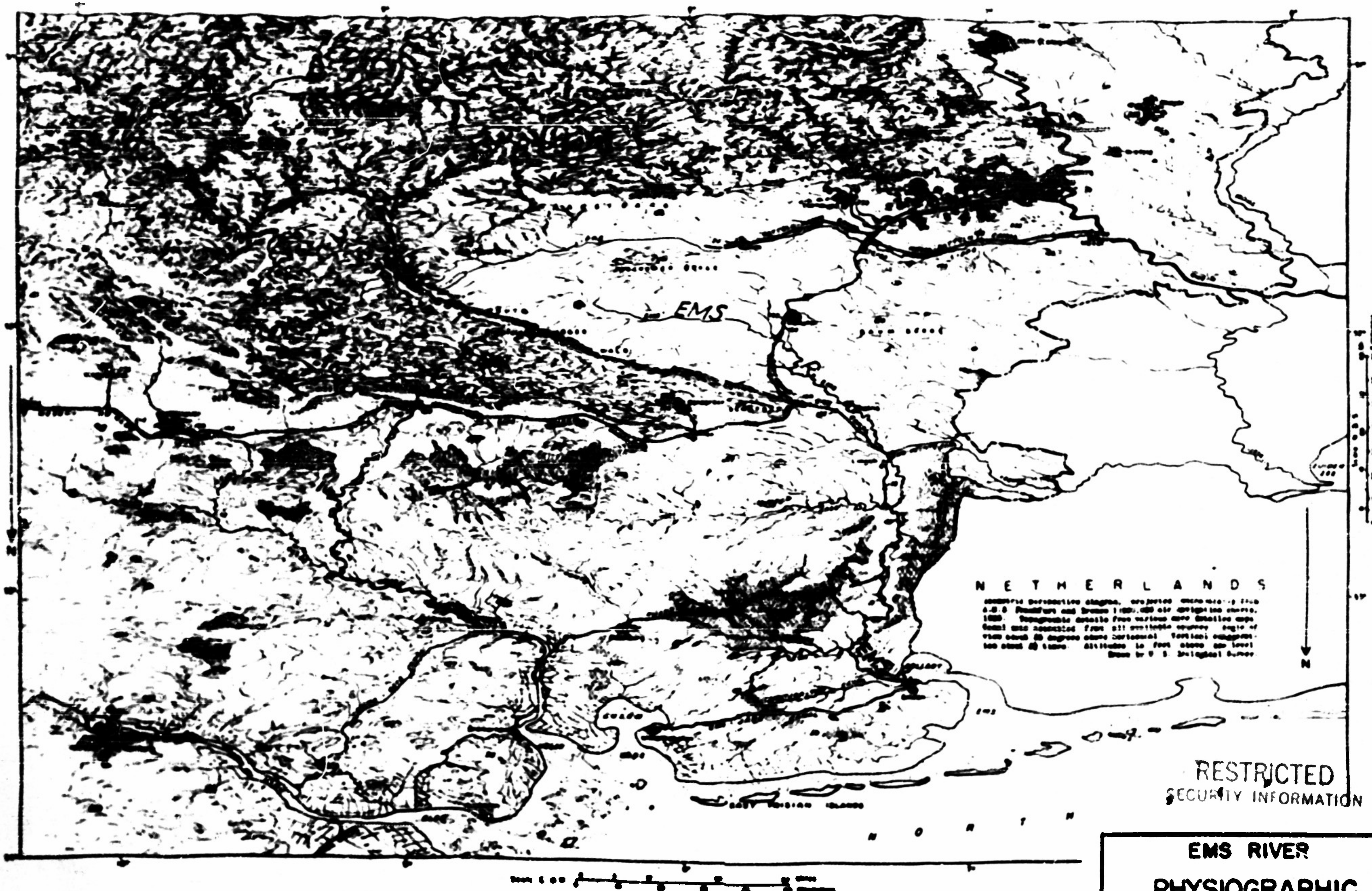
REPRODUCED FROM "REPORT ON RIVER EMS," G.S.I. (N)
MAIN HQ., 21ST ARMY GROUP. DECEMBER, 1945.

EMS RIVER

LOCATION PLAN
DORTMUND EMS CANAL

WASHINGTON DISTRICT CORPS OF ENGINEERS
Prepared by J.T.H. Date Aug 1952
Drawn by ______

PLATE 2



RESTRICTED
SECURITY INFORMATION

EMS RIVER

PHYSIOGRAPHIC DIAGRAM

WASHINGTON DISTRICT CORPS OF ENGINEERS

Prepared by J.J.H. Date Aug. 1952

Drawn by ______

PLATE 3

REPRODUCED FROM "NAVIGABLE WATERWAYS OF GERMANY"
S.E.S. 128, O.C.E., U.S.A., AUGUST, 1944.

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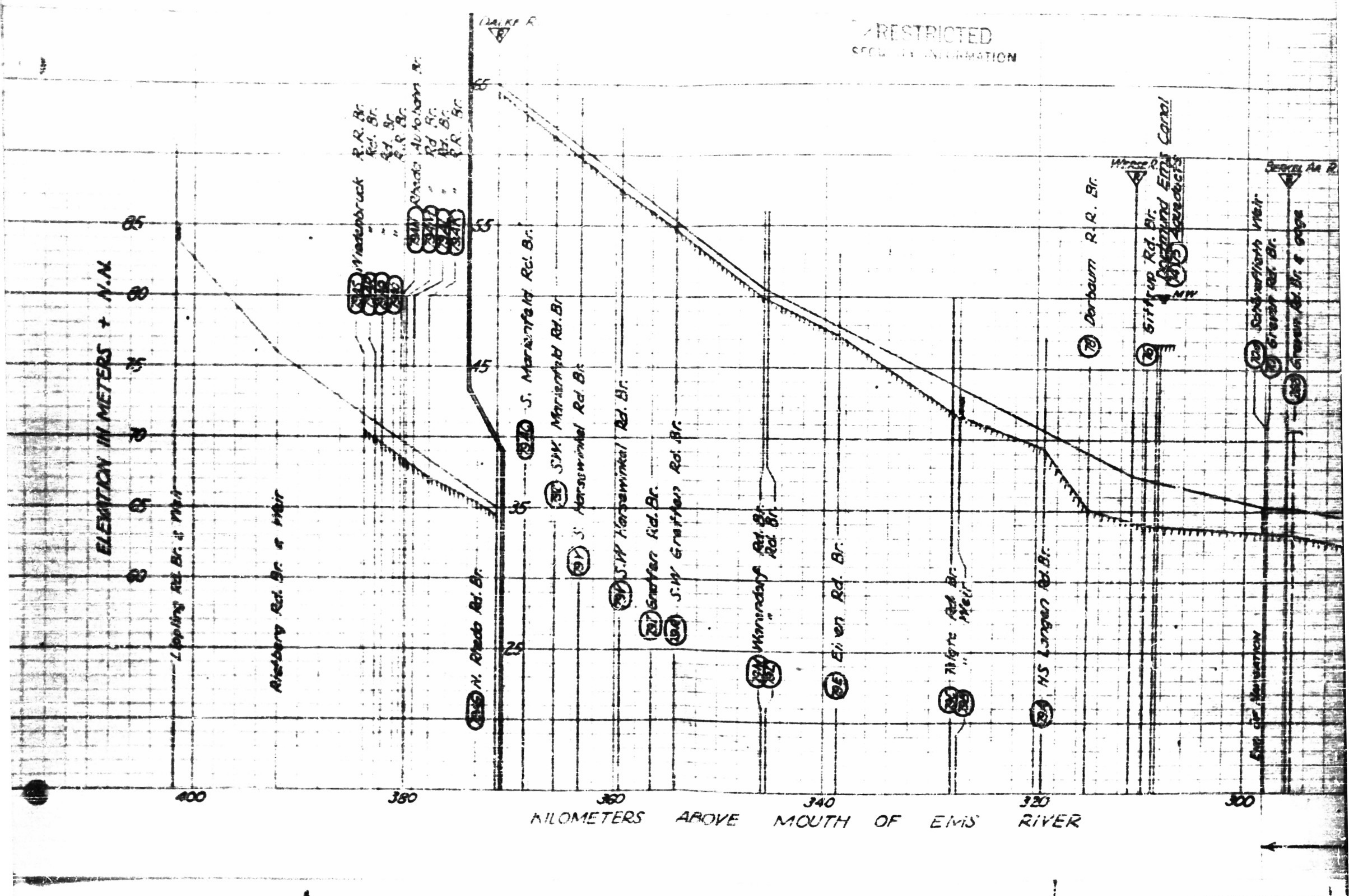
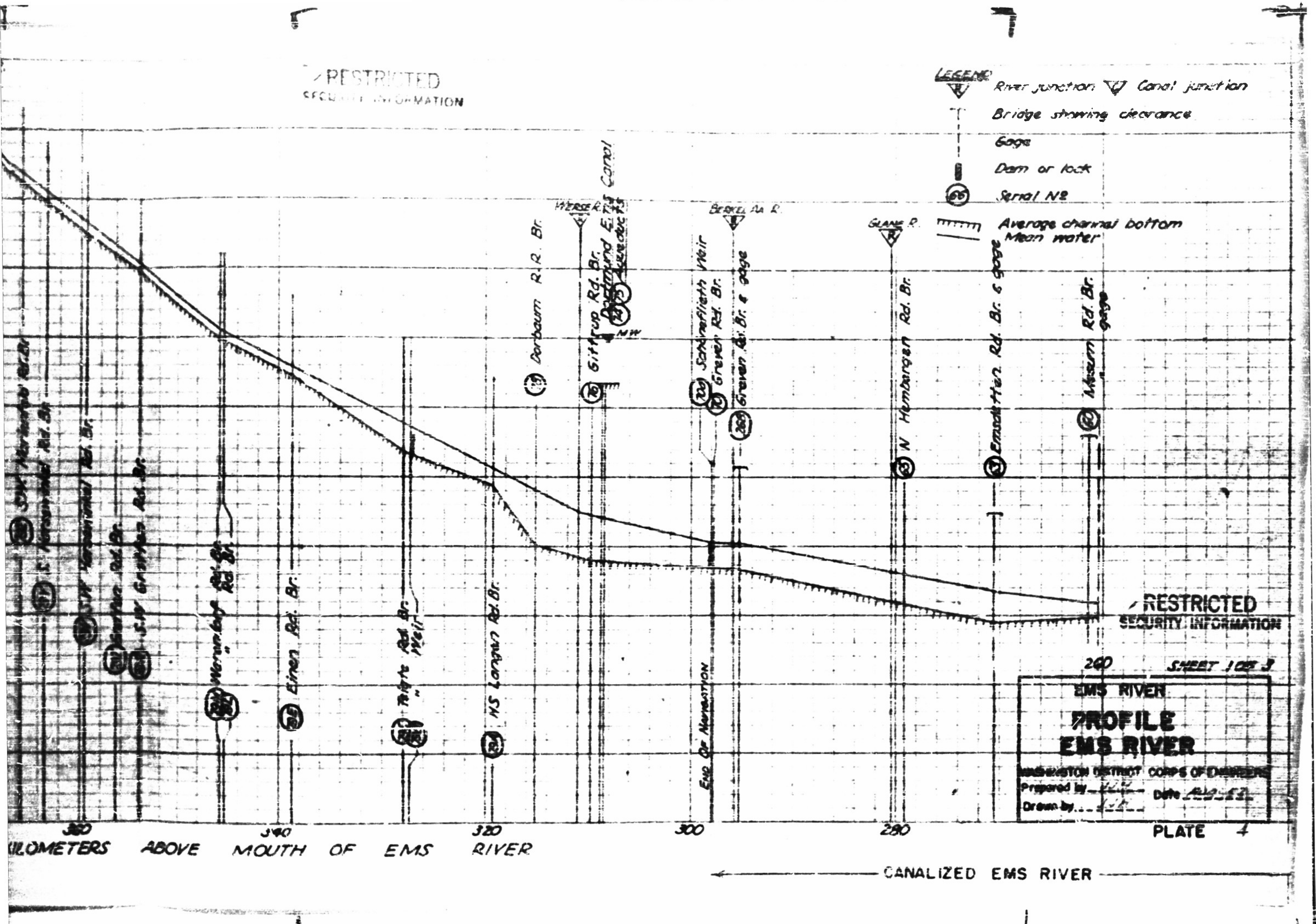
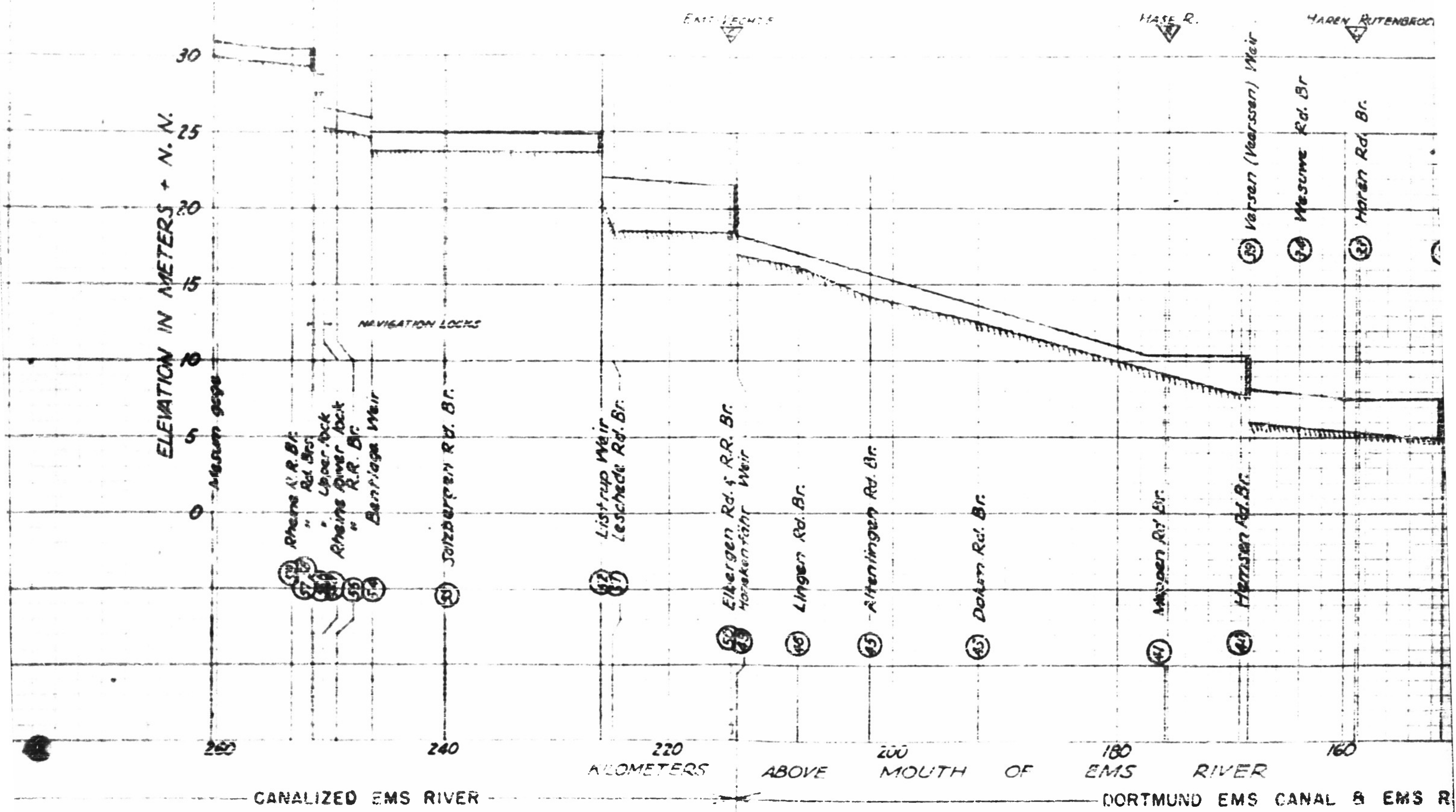
SECURITY INFORMATION



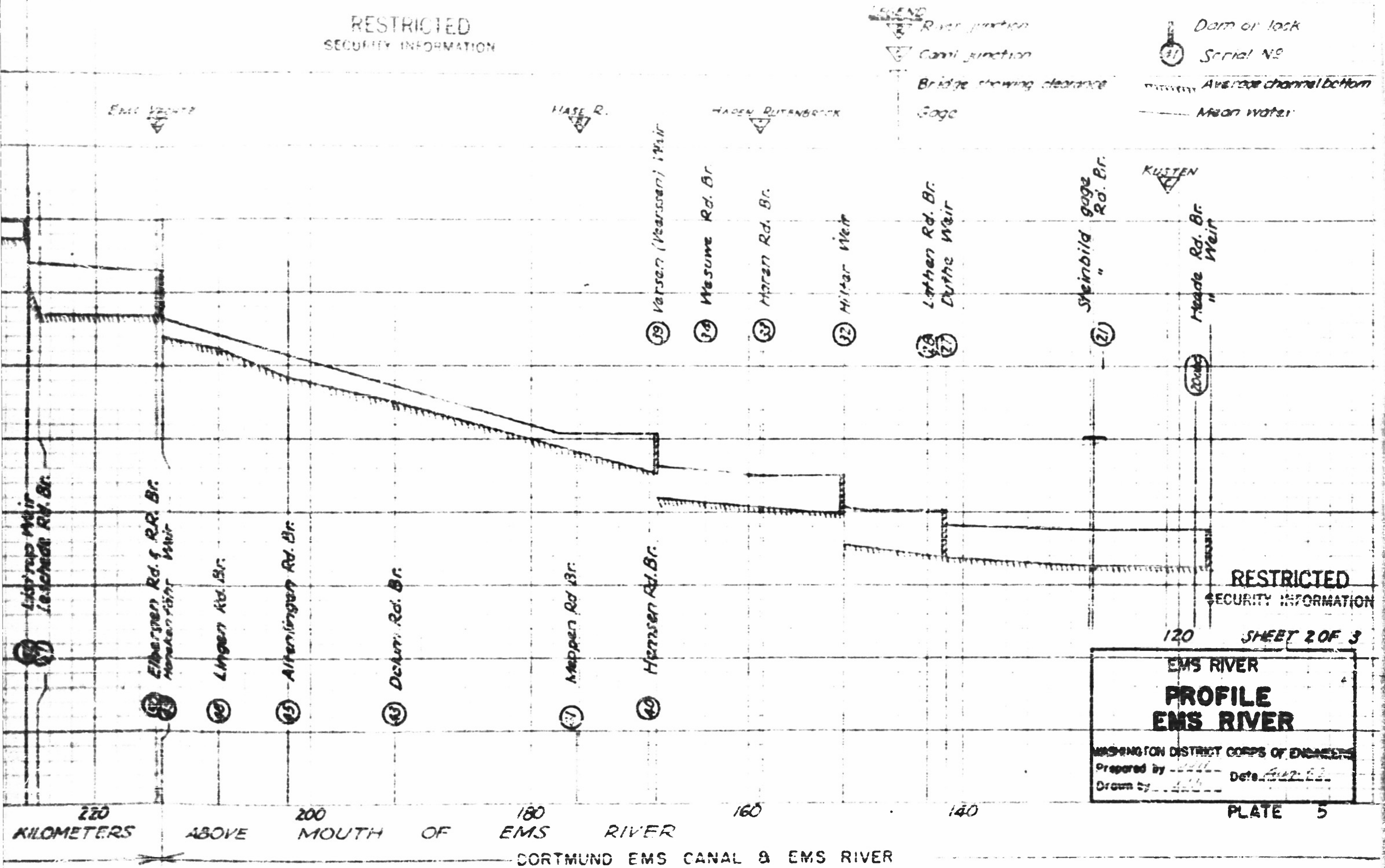


RESTRICTED
SECURITY INFORMATION
LEGEND
River junction
Canal junction
Bridge showing clearance
Gage
Dam or lock
Serial Nº
Average channel bottom
Mean water
WERSE R.
BERKEL AA R.
GLANE R.
Dortmund Ems Canal
Aqueducts
Dorbaum R.R. Br.
Gittrup Rd. Br.
Schöneflieth Weir
Greven Rd. Br.
Greven Rd. Br. & gage
N Hembergen Rd. Br.
Emsdetten Rd. Br. & gage
Mesum Rd. Br.
gage
Einen Rd. Br.
Weir
MS Langen Rd. Br.
End of Navigation
380
340
320
300
280
260
KILOMETERS ABOVE MOUTH OF EMS RIVER
CANALIZED EMS RIVER
SHEET 1 OF 3
EMS RIVER
PROFILE
EMS RIVER
WASHINGTON DISTRICT CORPS OF ENGINEERS
Prepared by
Drawn by
Date
PLATE 4

RESTRICTED
SECURITY INFORMATION



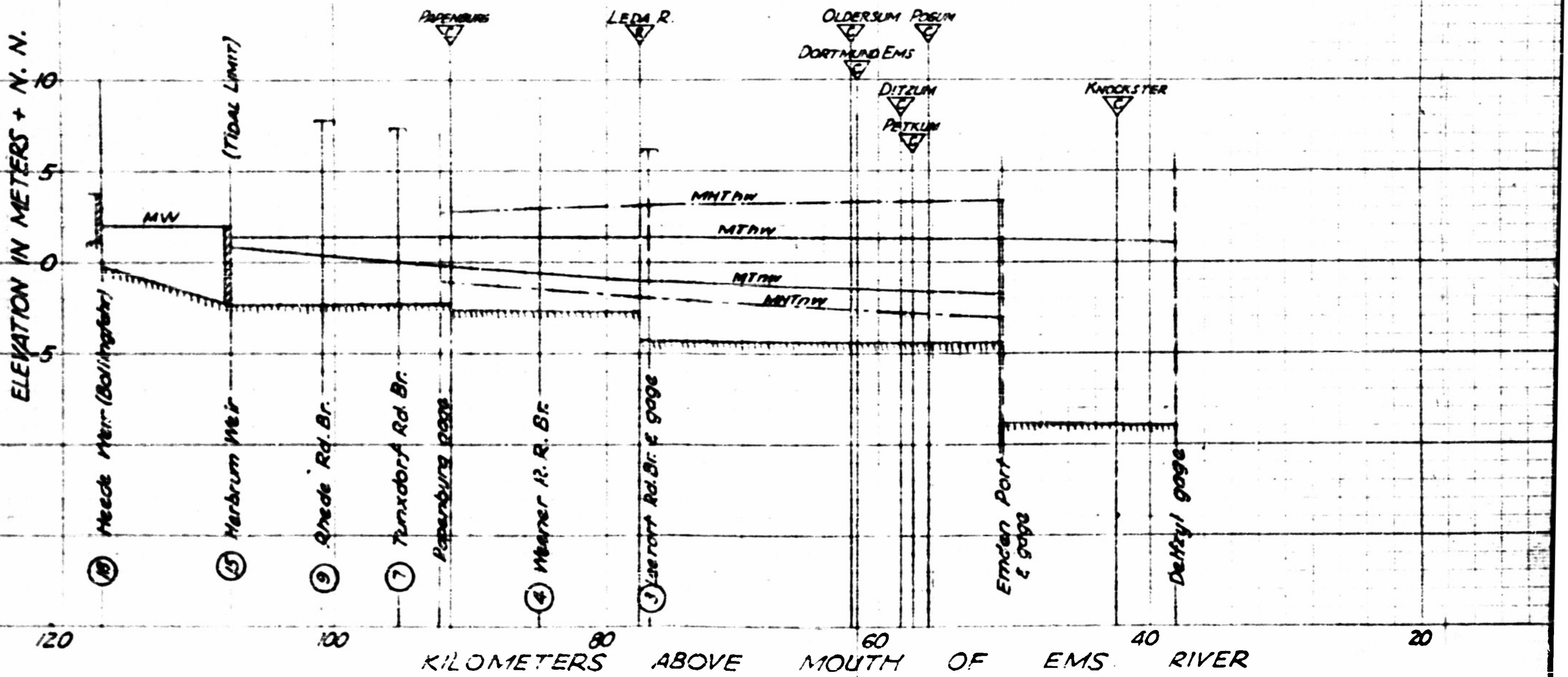
RESTRICTED
SECURITY INFORMATION



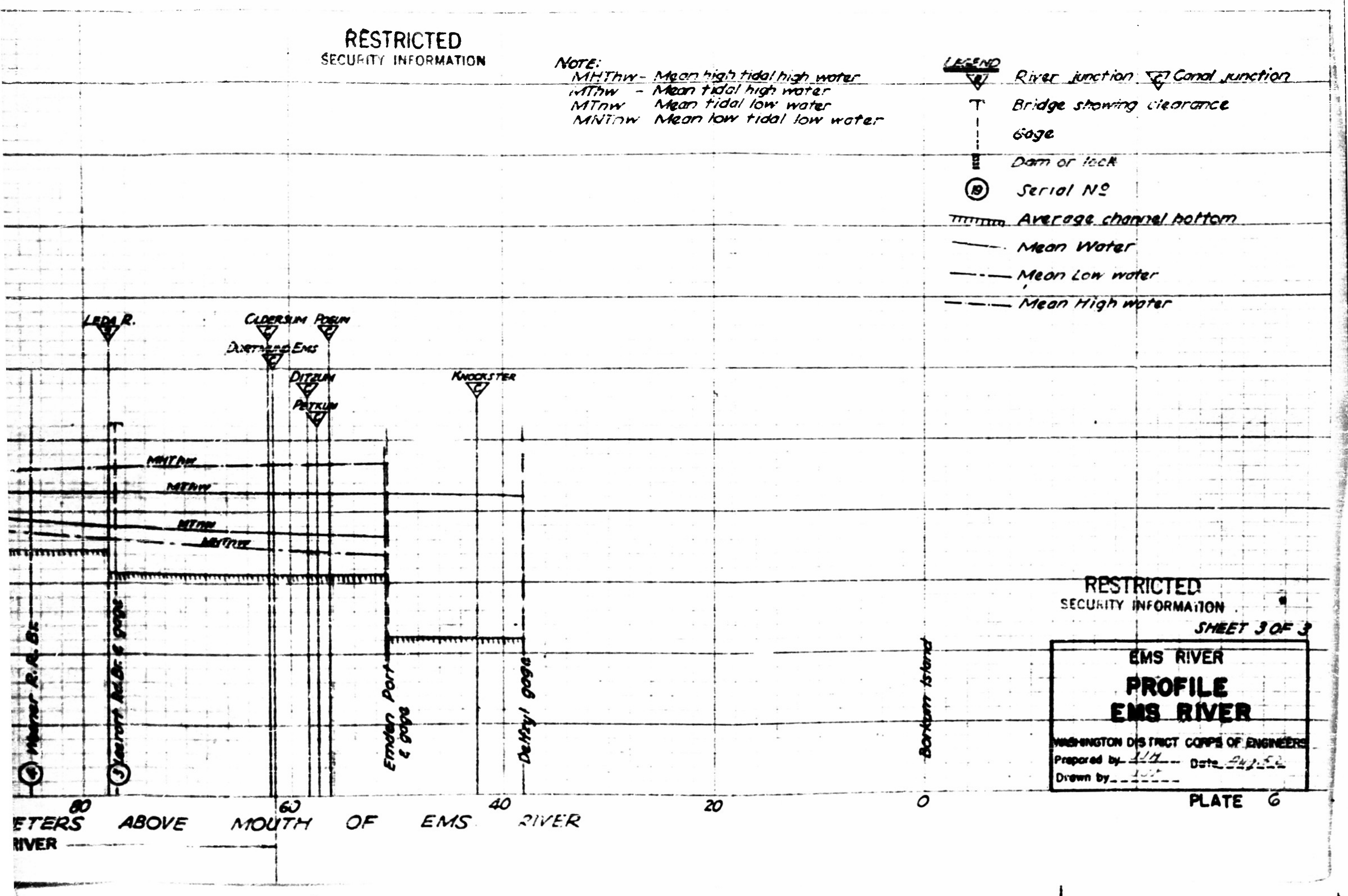
RESTRICTED
SECURITY INFORMATION

RESTRICTED
SECURITY INFORMATION

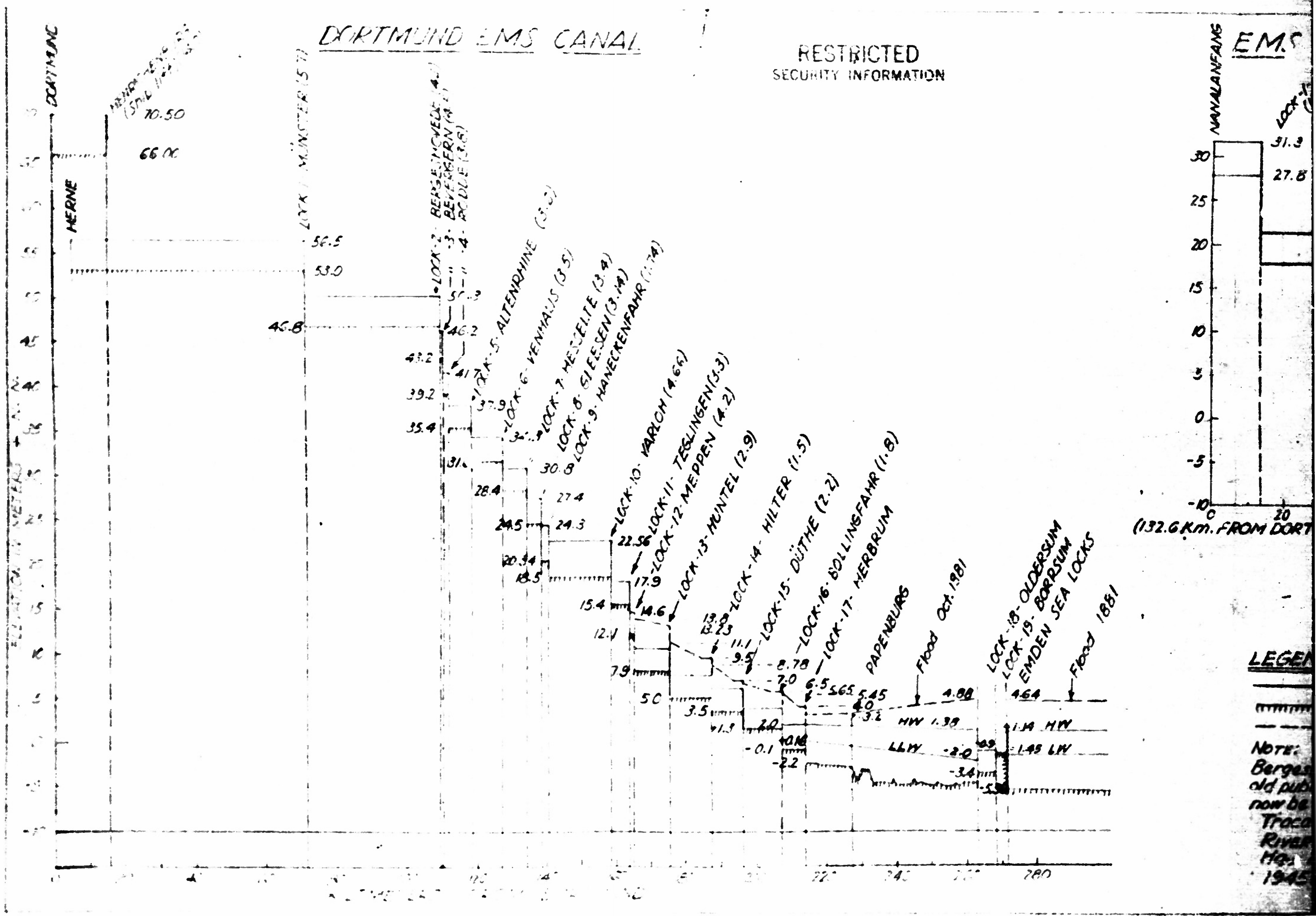
Note:
MHThw - Mean high tidal high w
MThw - Mean tidal high wate
MTnw Mean tidal low wate
MNTnw Mean low tidal low



DORTMUND EMS CANAL & EMS RIVER

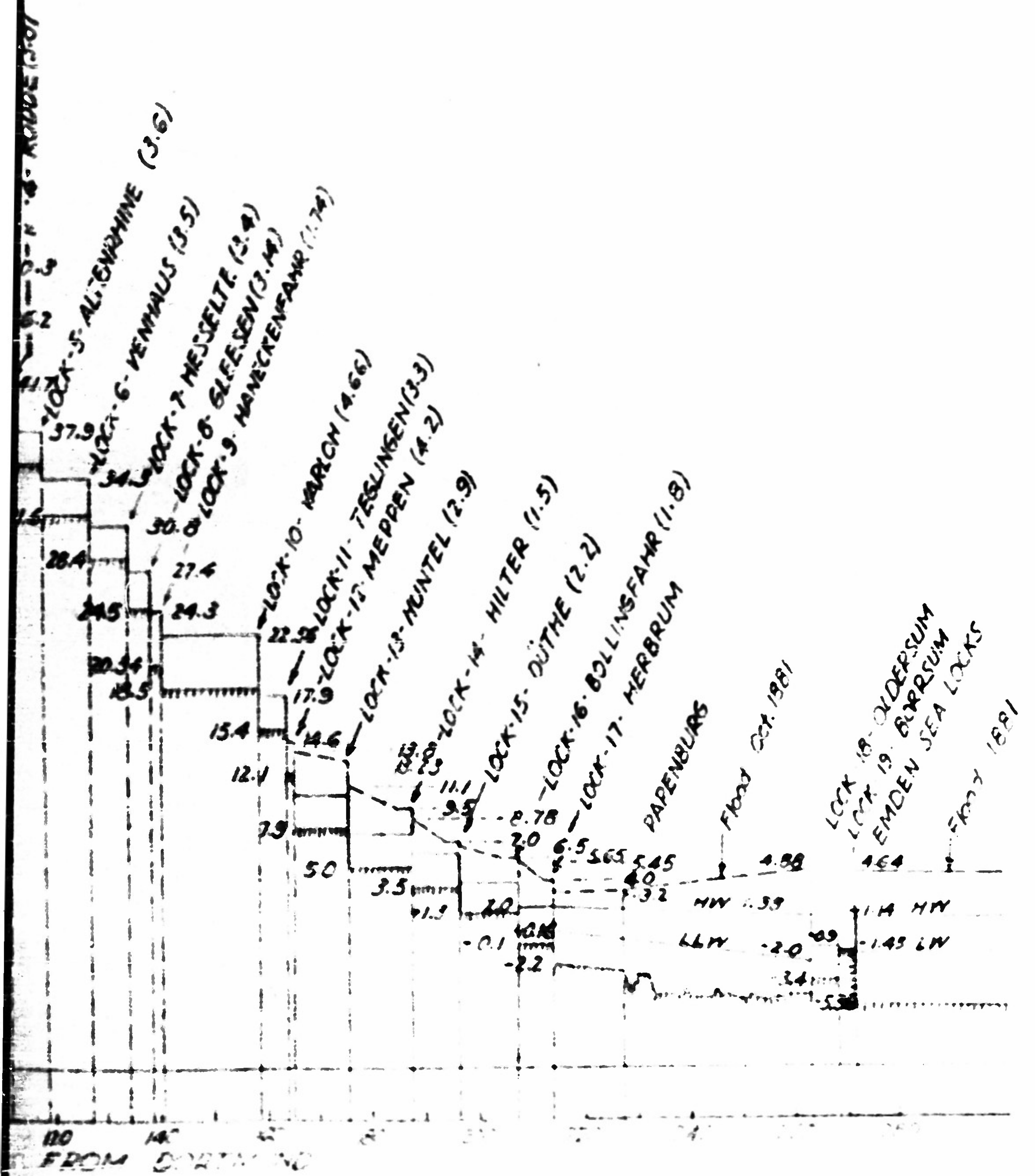

RESTRICTED
SECURITY INFORMATION
NOTE:
MHThw - Mean high tidal high water
MThw - Mean tidal high water
MTnw Mean tidal low water
MNTnw Mean low tidal low water
LEGEND
River junction
Canal junction
Bridge showing clearance
Gage
Dam or lock
Serial No
Average channel bottom
Mean Water
Mean Low water
Mean High water
LEDA R.
OLDERSUM
POGUM
DUETTING EMS
DITZUM
PETKUM
KNOCKSTER
MHThw
MThw
MTnw
MNTnw
Weener R.R. Br.
Leerort Rd. Br. & gage
Emden Port & gage
Delfzyl gage
Borkum Island
80
60
40
20
0
...ETERS ABOVE MOUTH OF EMS RIVER
...RIVER
RESTRICTED
SECURITY INFORMATION
SHEET 3 OF 3
EMS RIVER
PROFILE
EMS RIVER
WASHINGTON DISTRICT CORPS OF ENGINEERS
Prepared by
Date
Drawn by
PLATE 6

RESTRICTED
SECURITY INFORMATION

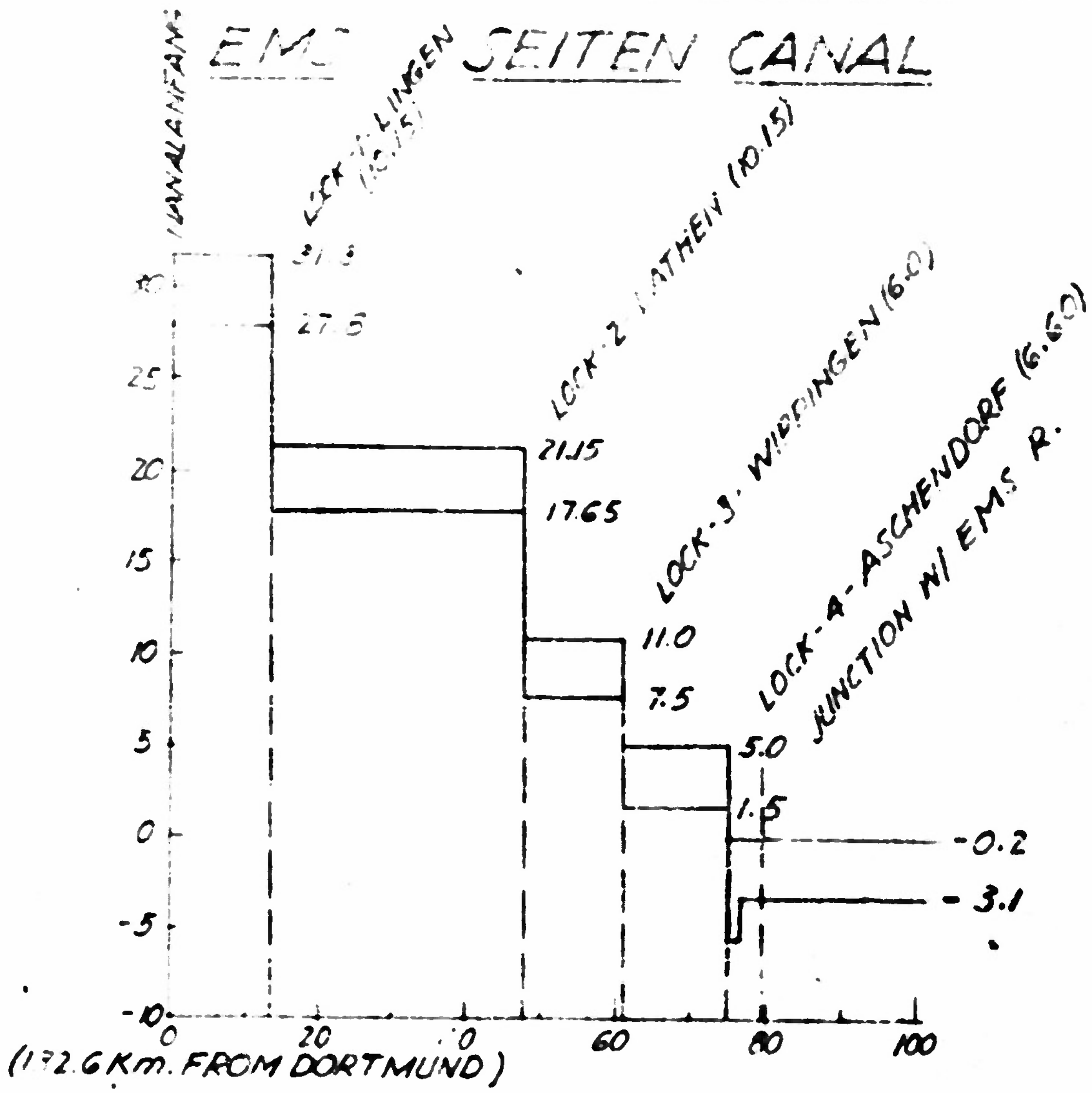


EMS CANAL

RESTRICTED
SECURITY INFORMATION



EMS SEITEN CANAL



LEGEND

Water level
Bed level
Flood level

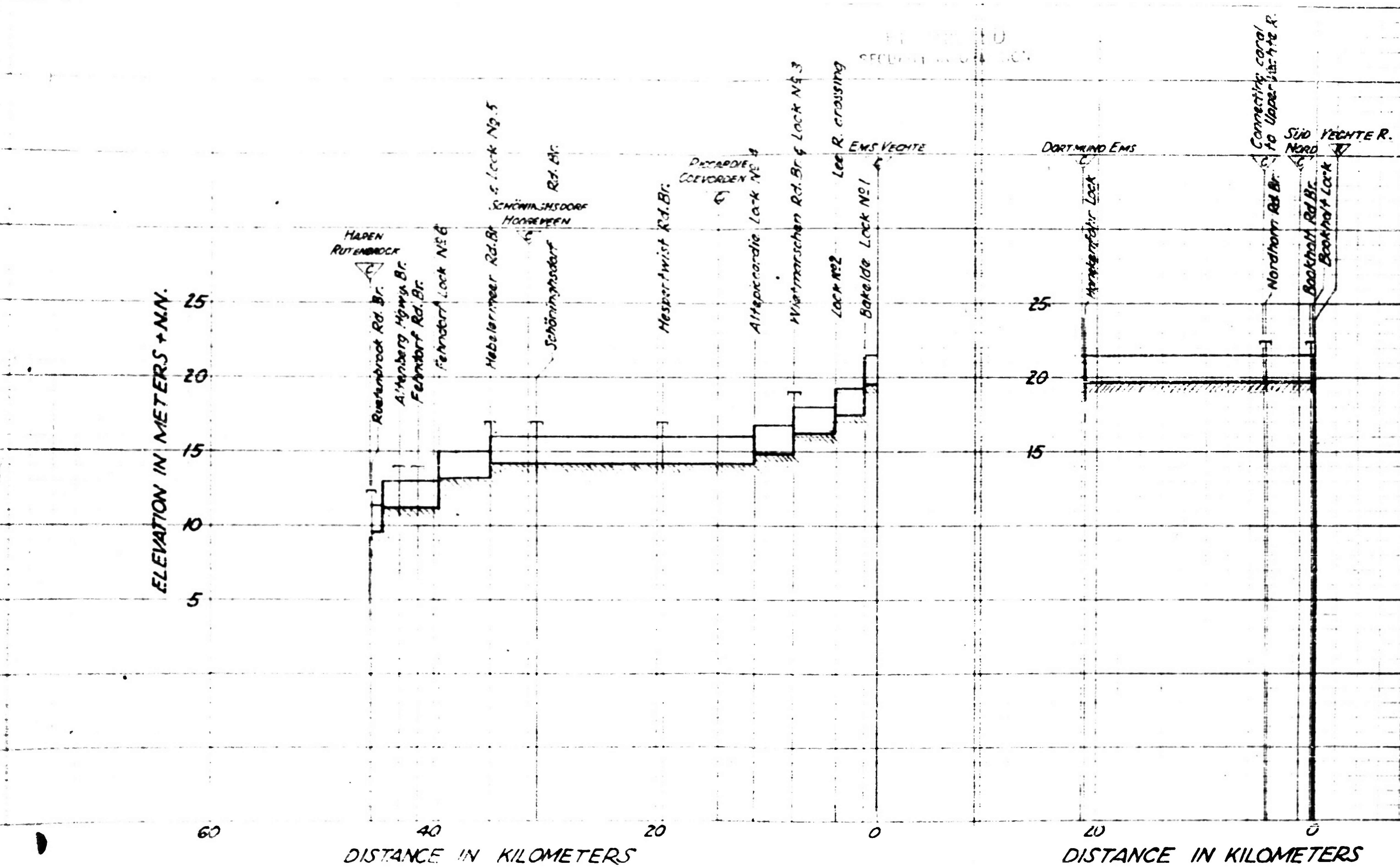
NOTE: Bed levels below Bergeshovede are from an old publication. Depths may now be increased.

Traced from "REPORT ON RIVER EMS," G.S.I. (RE) Main Hq., 21st Army Group. Dec. 1945.

RESTRICTED
SECURITY INFORMATION

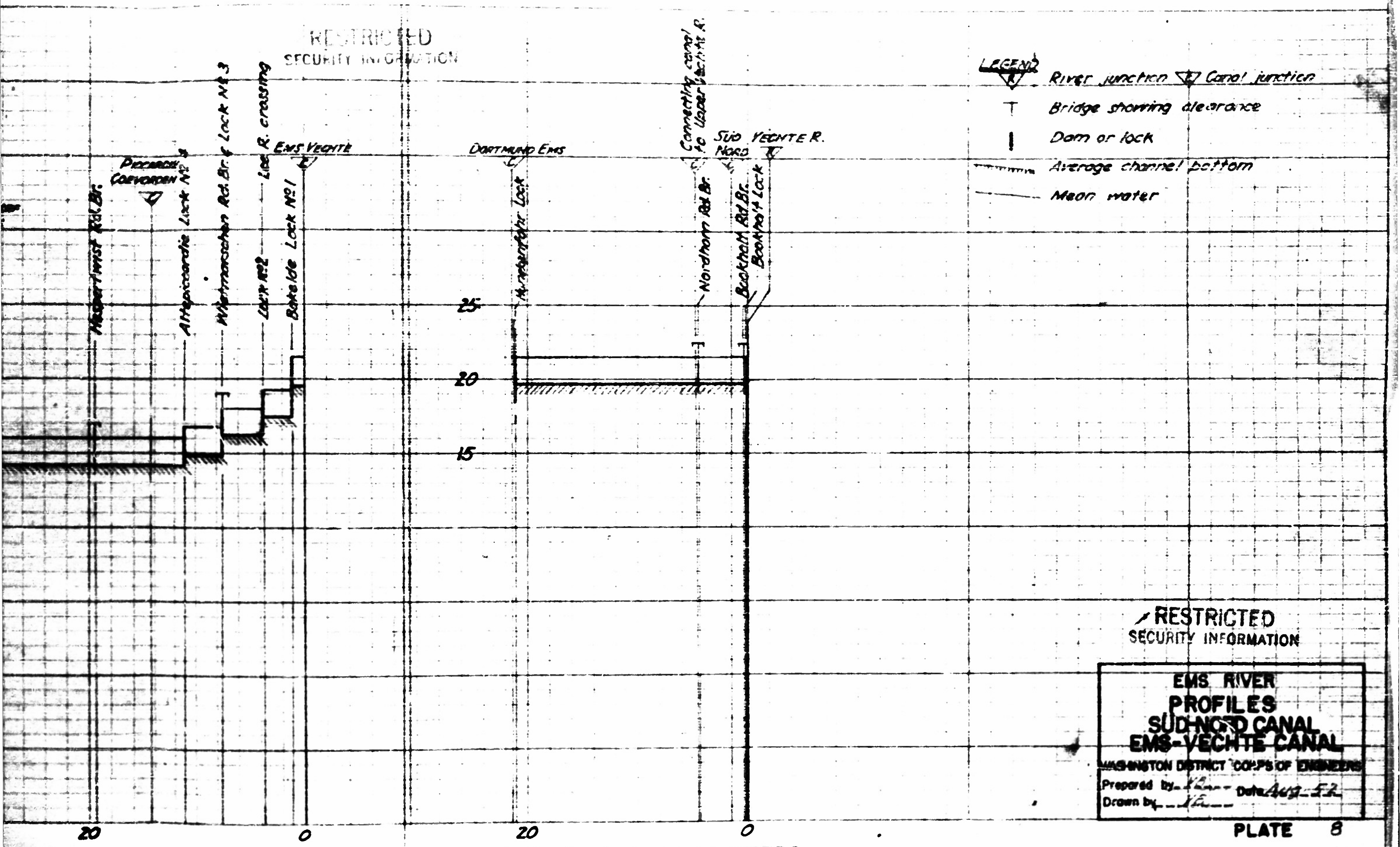
EMS RIVER
PROFILE
DORTMUND-EMS & EMS-SEITEN CANALS
WASHINGTON DISTRICT CORPS OF ENGINEERS
Prepared by J.J.H.
Drawn by ________ Date Aug. 52

PLATE 7



SÜD-NORD CANAL

EMS-VECHTE CANAL



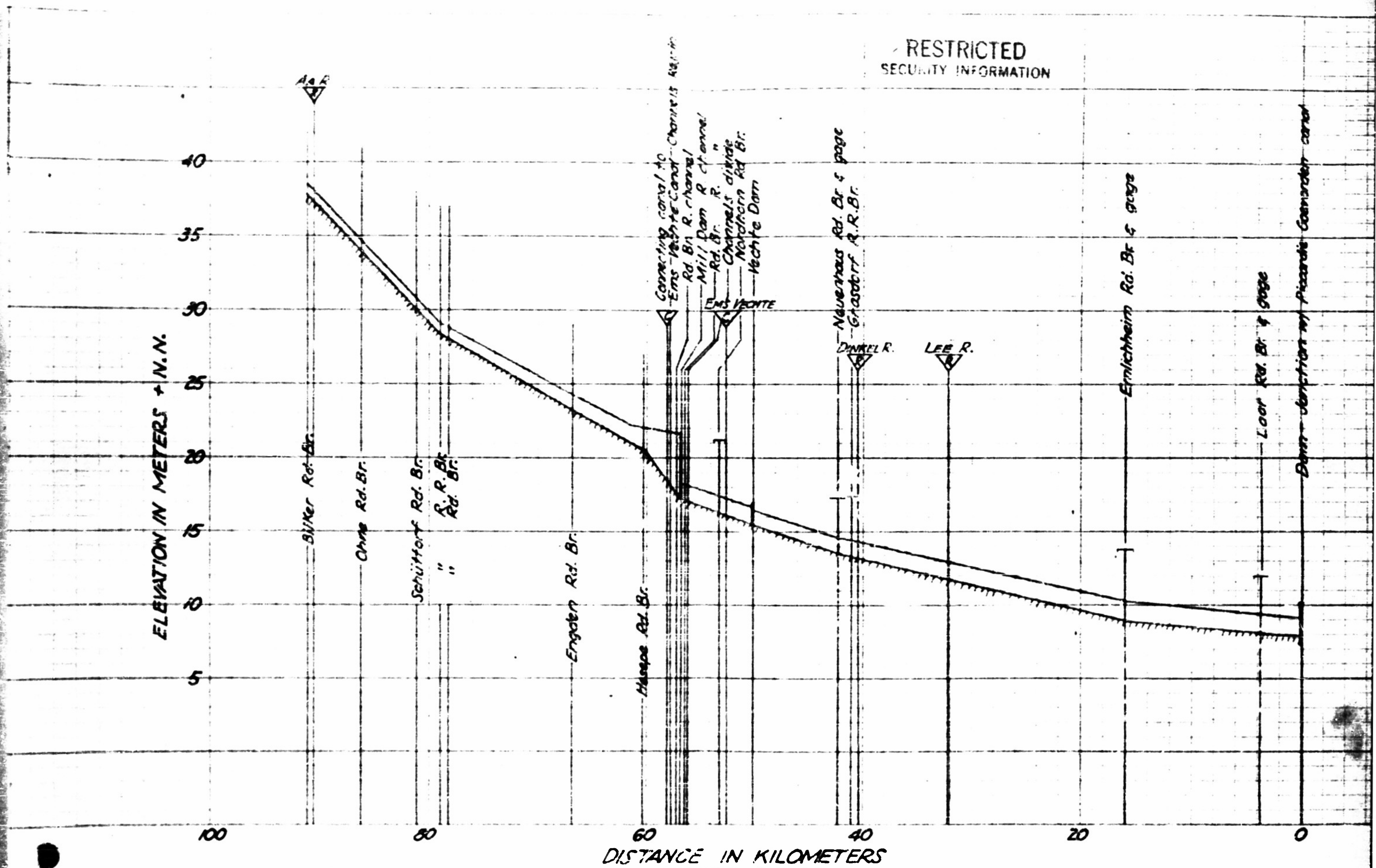
ETERS
NAL

DISTANCE IN KILOMETERS
EMS-VECHTE CANAL

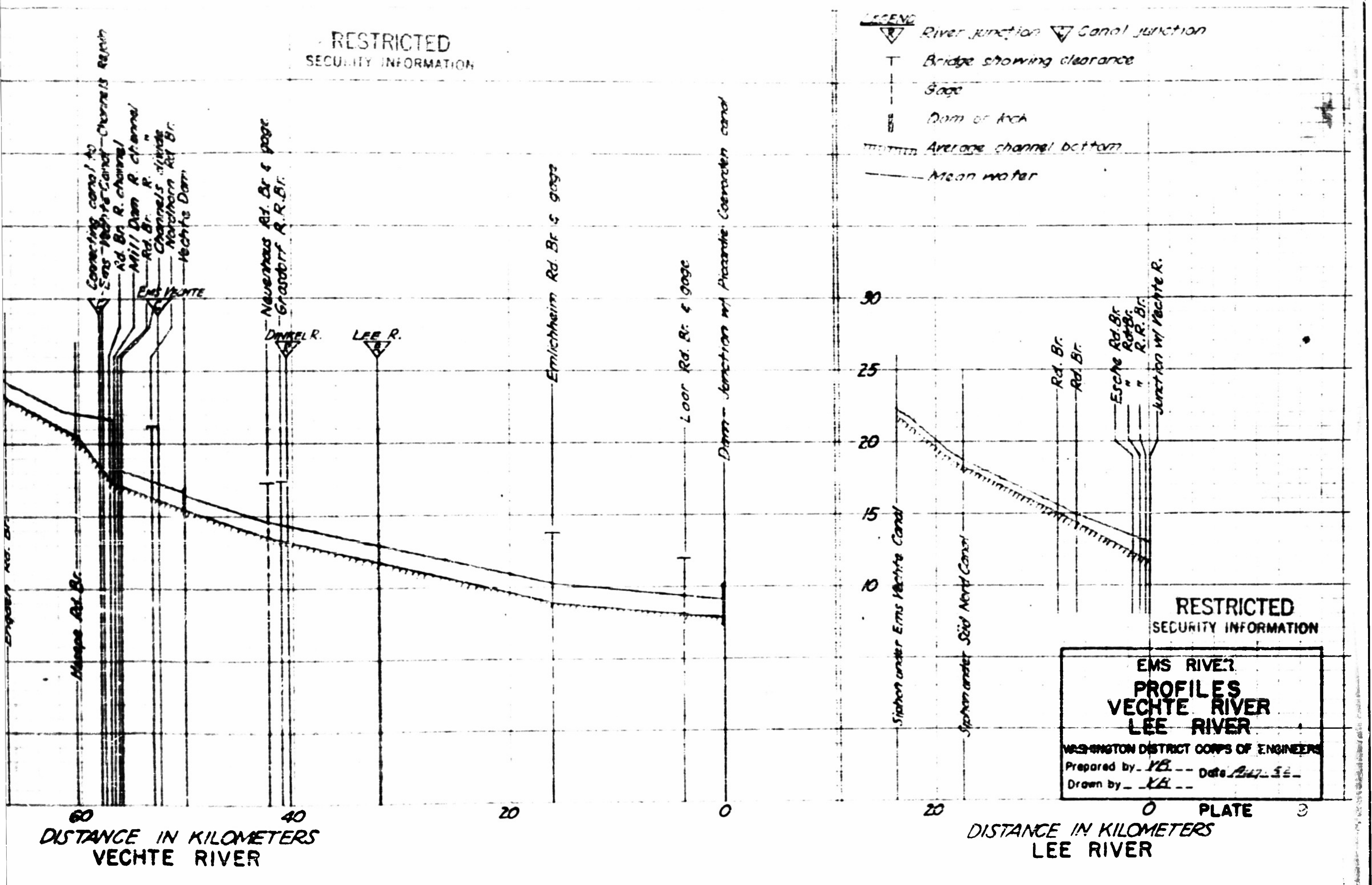
EMS RIVER
PROFILES
SÜD-NORD CANAL
EMS-VECHTE CANAL
WASHINGTON DISTRICT CORPS OF ENGINEERS
Prepared by KE Date Aug 52
Drawn by KE

PLATE 8

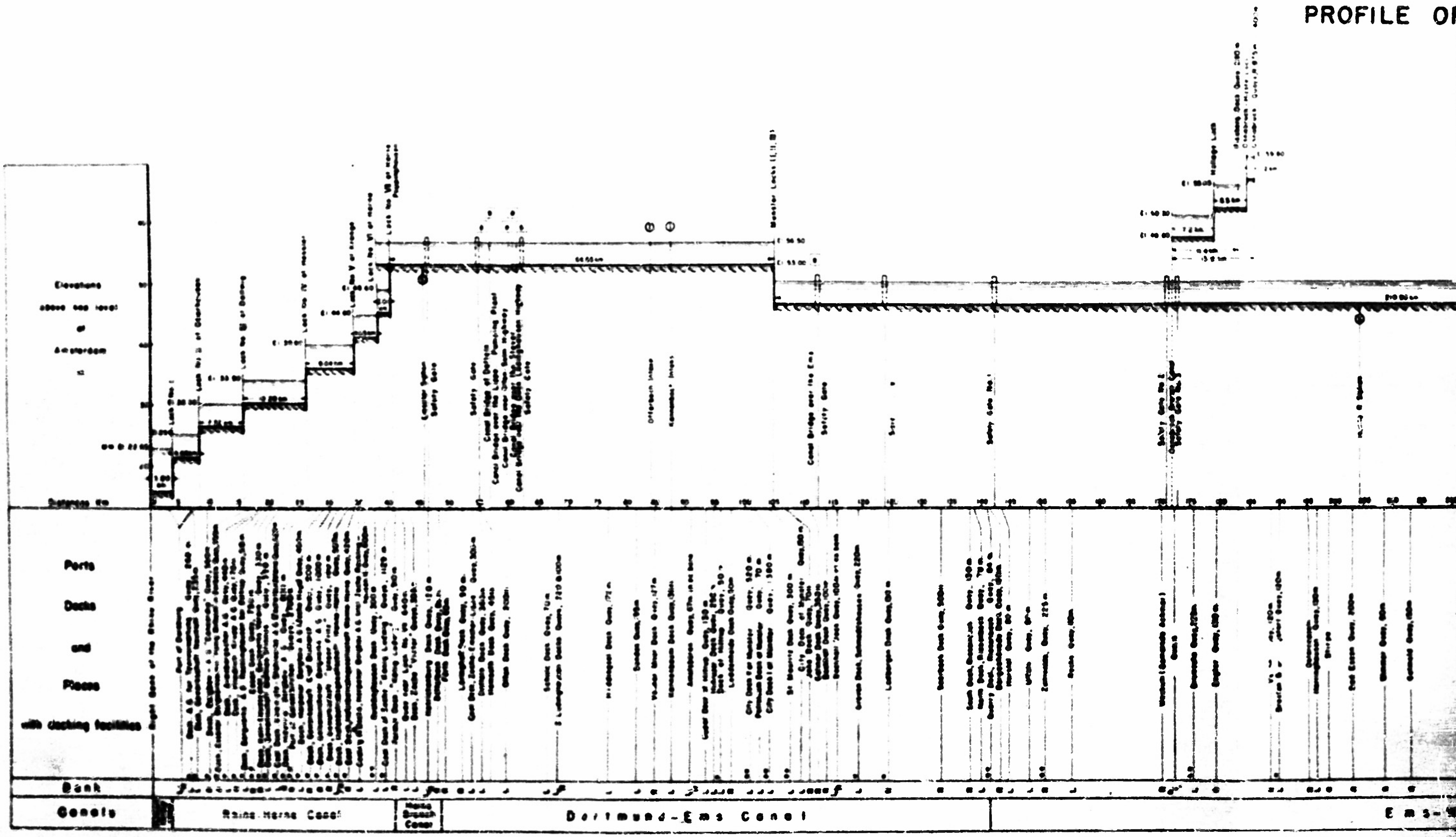
RESTRICTED
SECURITY INFORMATION



VECHTE RIVER



RESTRICTED
SECURITY INFORMATION
LEGEND
River junction
Canal junction
Bridge showing clearance
Gage
Dam or lock
Average channel bottom
Mean water
Connecting canal to Ems-Vechte Canal - Channels Rejoin
Rd. Br. R. channel
Mill Dam R. channel
Rd. Br. R. "
Channels Rejoin
Nordhorn Rd. Br.
Vechte Dam
EMS VECHTE
Neuenhaus Rd. Br. & gage
Grasdorf R.R. Br.
DINKEL R.
LEE R.
Emlichheim Rd. Br. & gage
Loor Rd. Br. & gage
Dam - Junction w/ Piccardie Coevorden canal
Rd. Br.
Siphon under Ems Vechte Canal
Siphon under Süd Nord Canal
Rd. Br.
Rd. Br.
Esche Rd. Br.
" Rd. Br.
" R.R. Br.
Junction w/ Vechte R.
30
25
20
15
10
60
40
20
0
DISTANCE IN KILOMETERS
VECHTE RIVER
20
0
DISTANCE IN KILOMETERS
LEE RIVER
RESTRICTED
SECURITY INFORMATION
EMS RIVER
PROFILES
VECHTE RIVER
LEE RIVER
WASHINGTON DISTRICT CORPS OF ENGINEERS
Prepared by VB Date Aug 52
Drawn by VB
PLATE 3


PROFILE OF
Elevations
above sea level
of
Amsterdam
m
Ports
Docks
and
Places
with docking facilities
Bank
Canals
Rhine-Herne Canal
Hamm Branch Canal
Dortmund-Ems Canal
Ems-W

RESTRICTED

PROFILE OF THE MITTELLAND CANAL

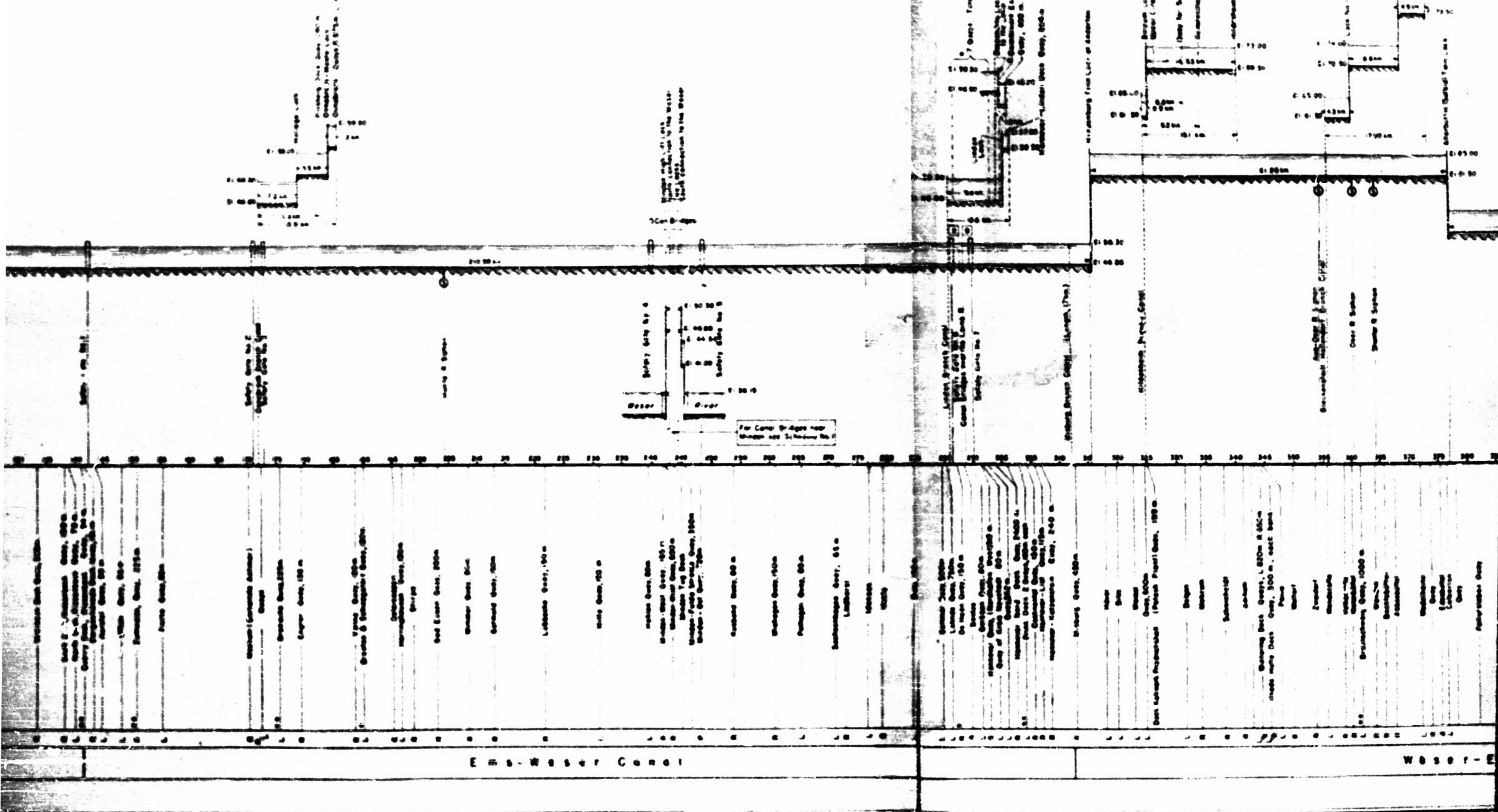


FIG 15-4

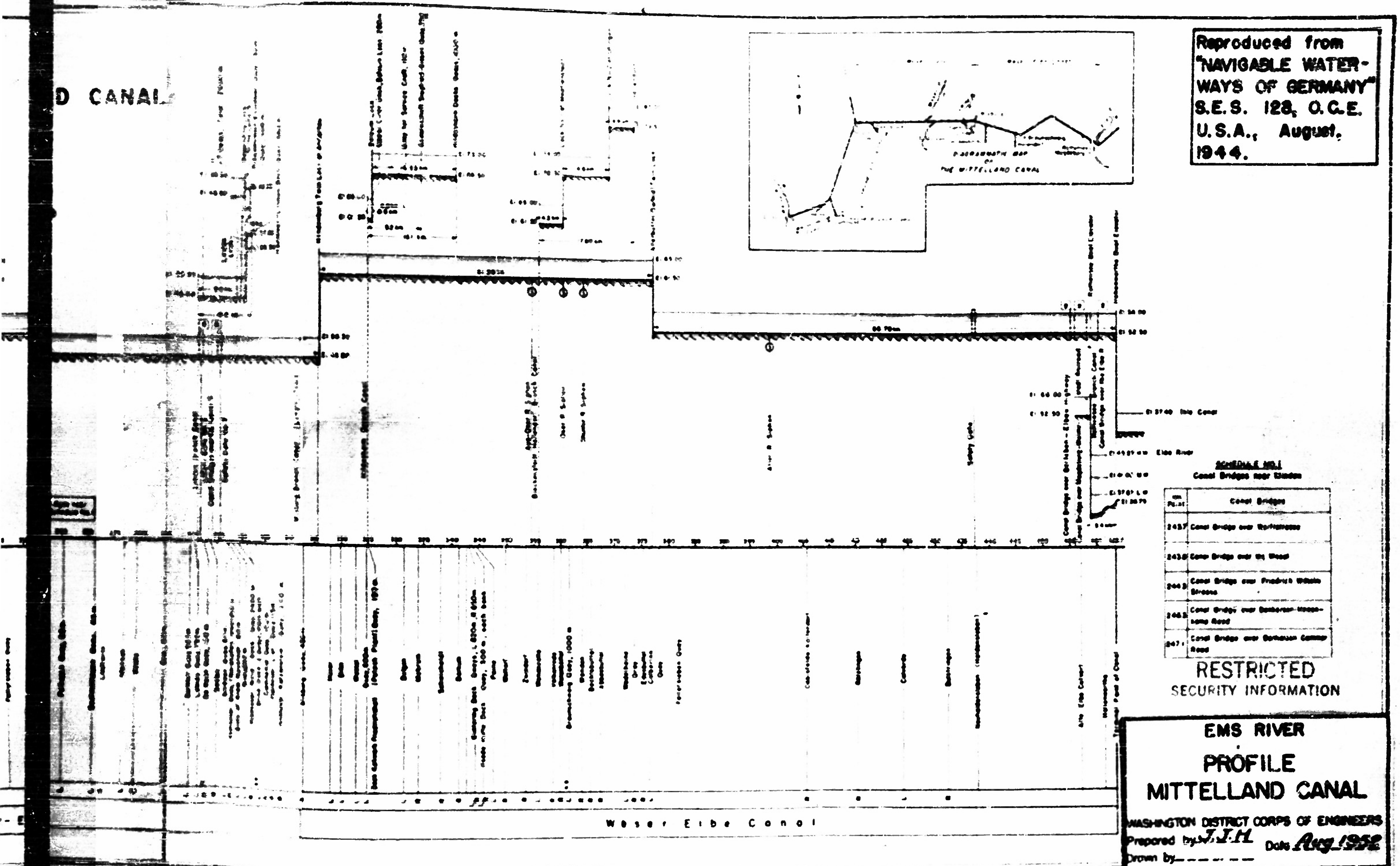

D CANAL
Reproduced from "NAVIGABLE WATER-WAYS OF GERMANY" S.E.S. 128, O.C.E. U.S.A., August, 1944.
Weser Elbe Canal
RESTRICTED
SECURITY INFORMATION
EMS RIVER
PROFILE
MITTELLAND CANAL
WASHINGTON DISTRICT CORPS OF ENGINEERS
Prepared by J.J.H. Date Aug 1952
Drawn by

PLATE 10

RESTRICTED
SECURITY INFORMATION

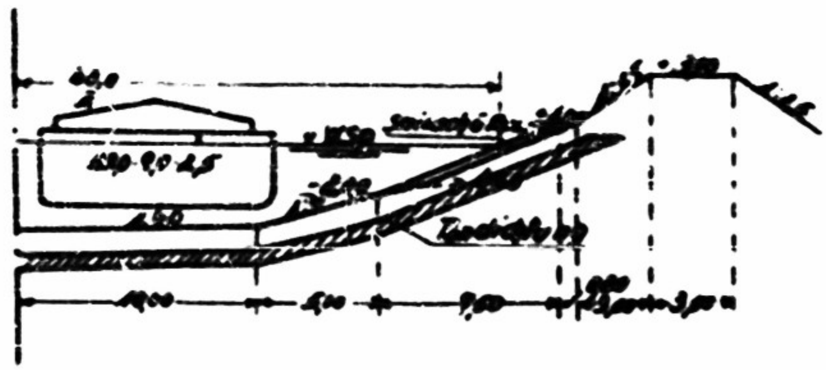


Fig. 13-2
Cross Section of Water Prism of the Reconstructed
Dortmund-Ems Canal
V-802 p.93 (1930)

Fig. 13-3
Typical Cross Section of Water Prism of the Reconstructed
Dortmund-Ems Canal

One of the banks is protected by steel sheet piling to reduce the volume of excavation.
V-481 p.130 (1936)

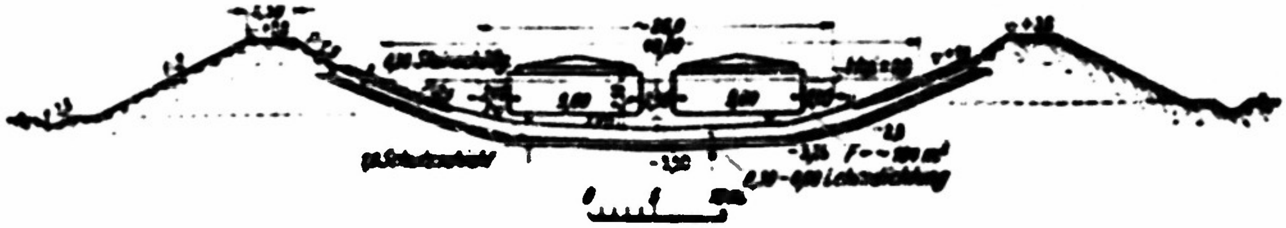


Fig. 13-4
Typical Cross Section of a New By-Pass Canals
Dortmund-Ems Canal

Lehmdichtung:	Clay lining
Schutzschicht:	Protective layer
Steinschüttung:	Broken stone

REPRODUCED FROM "NAVIGABLE WATERWAYS OF GERMANY" S.S.S. 129, O.C.E., U.S.A., AUGUST, 1944.

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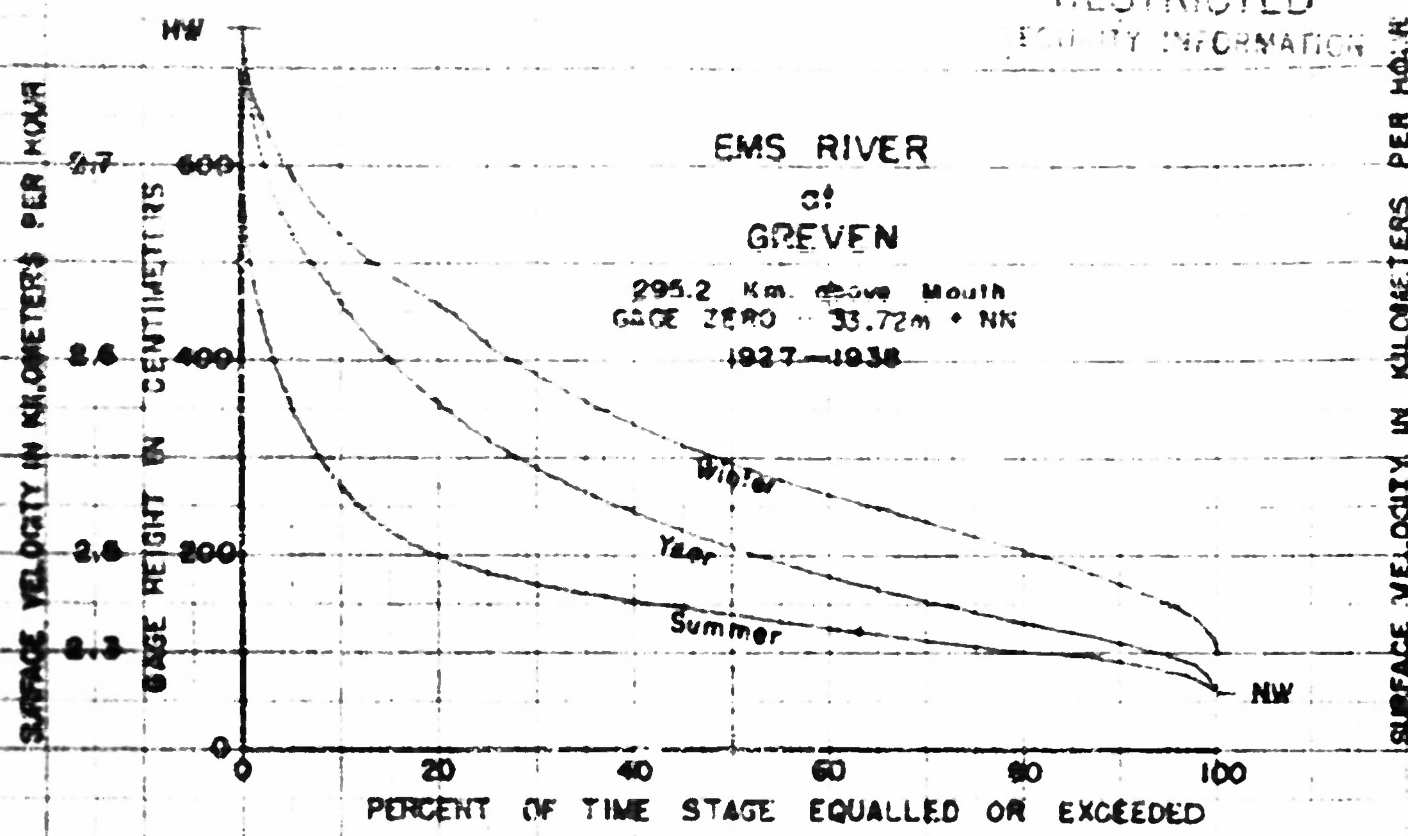
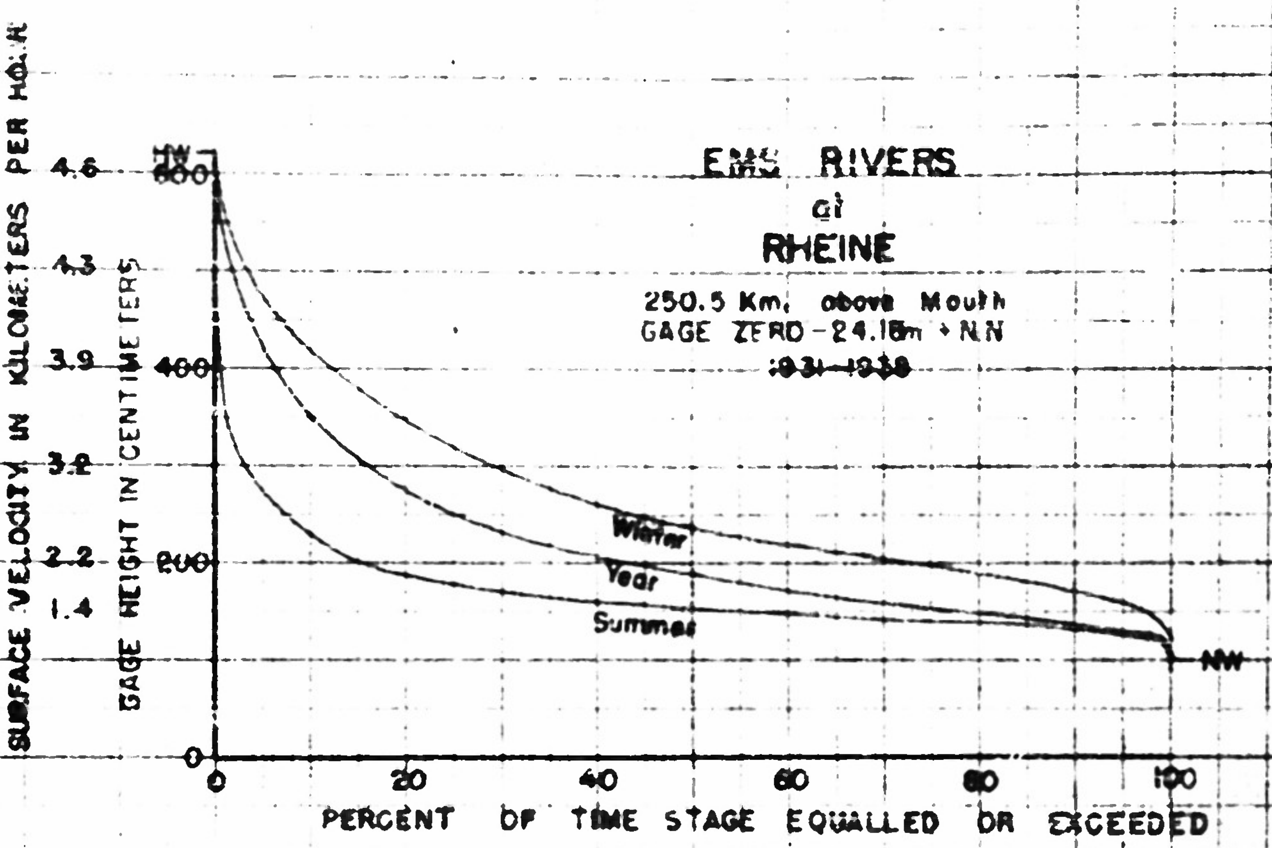
SECURITY INFORMATION

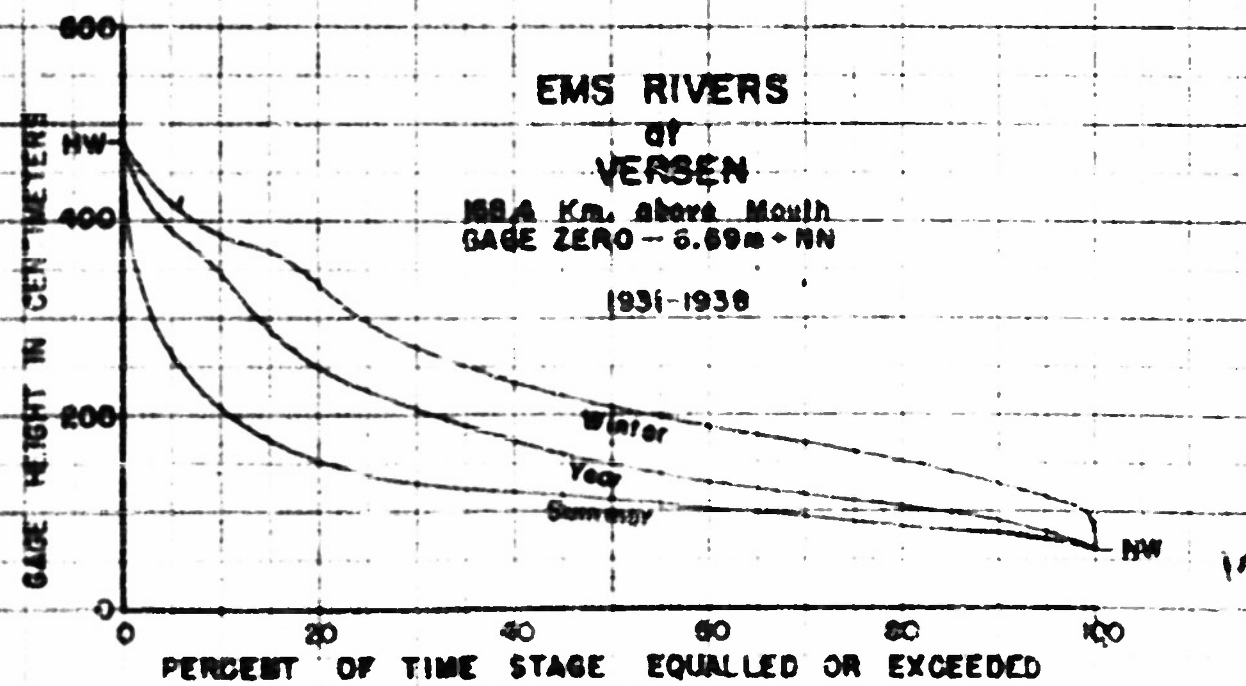
EMS RIVER
CROSS SECTIONS
DORTMUND EMS CANAL
WASHINGTON DISTRICT CORPS OF ENGINEERS
Prepared by J.E.H. Date Aug. 1952
Drawn by ______

PLATE 11

RESTRICTED
SECURITY INFORMATION







RESTRICTED
SECURITY INFORMATION

EMS RIVER

STAGE DURATION CURVES

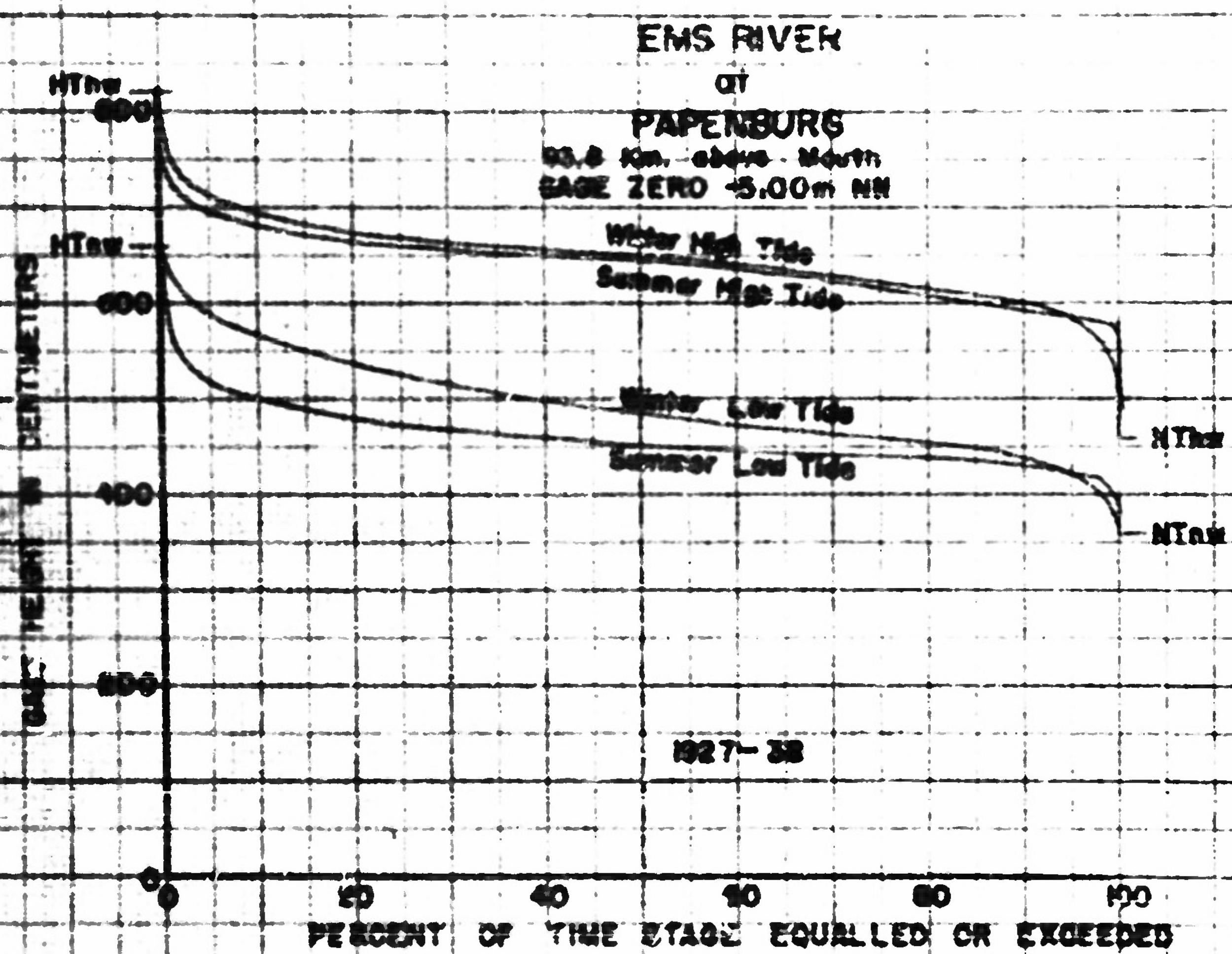
WASHINGTON DISTRICT CORPS OF ENGINEERS

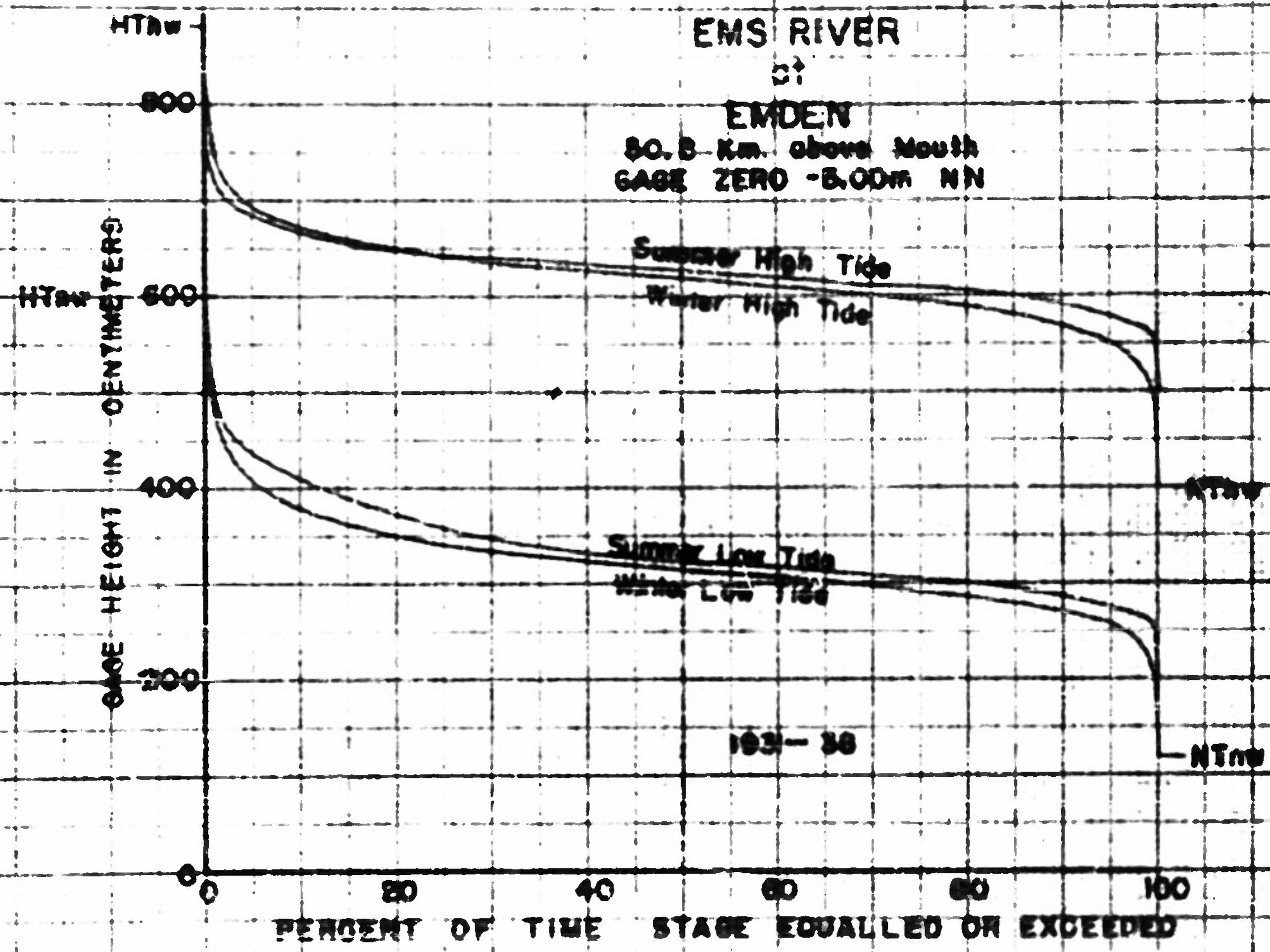
Prepared by *V.B.* Date *Aug. 1952*

Drawn by *J.J.H.*

PLATE 12

RESTRICTED
SECURITY INFORMATION





NOTE: 1. Duration curves for entire year would be approximately midway between the corresponding seasonal curves.

2. See Table 2 for definition of abbreviations.

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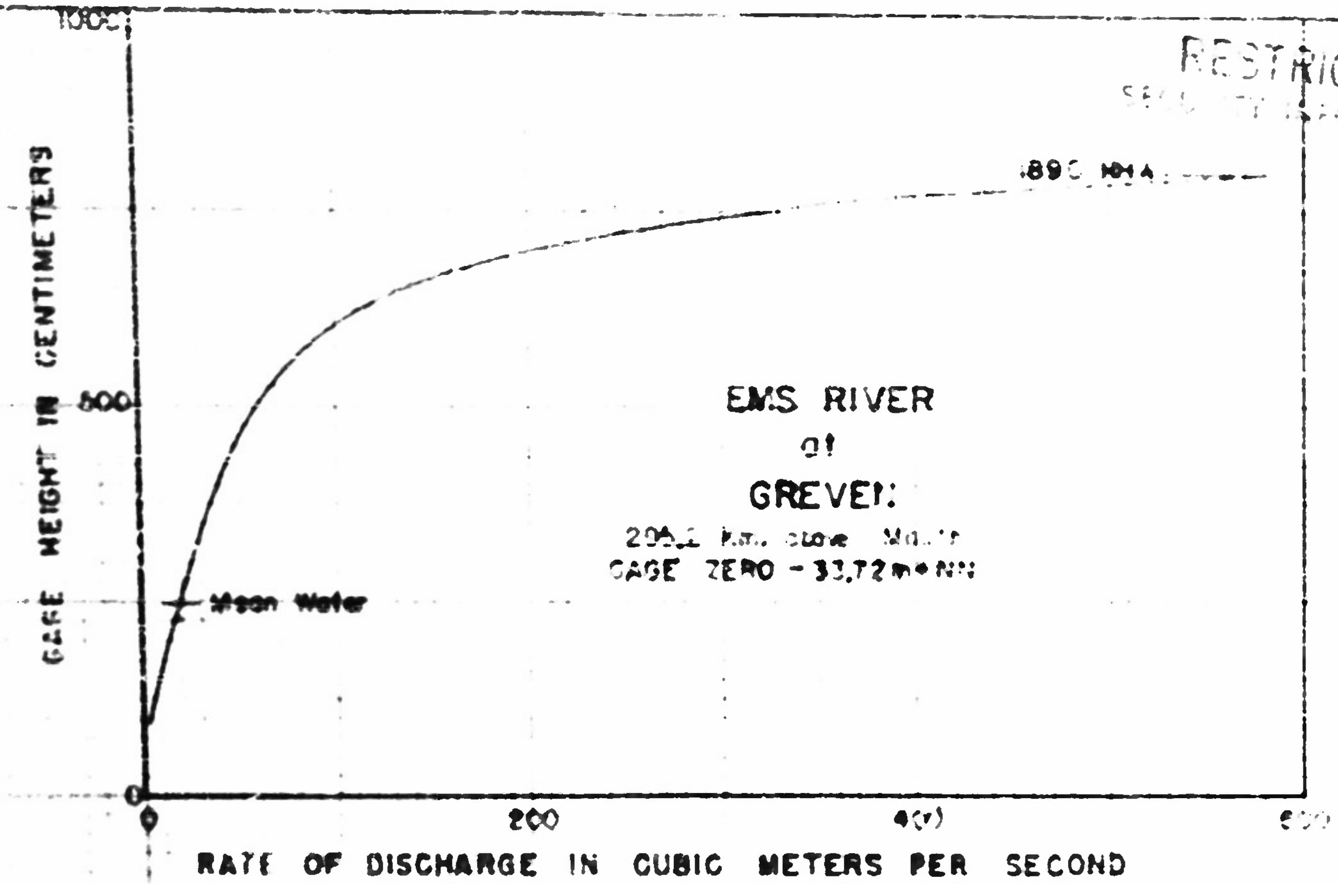
EMS RIVER

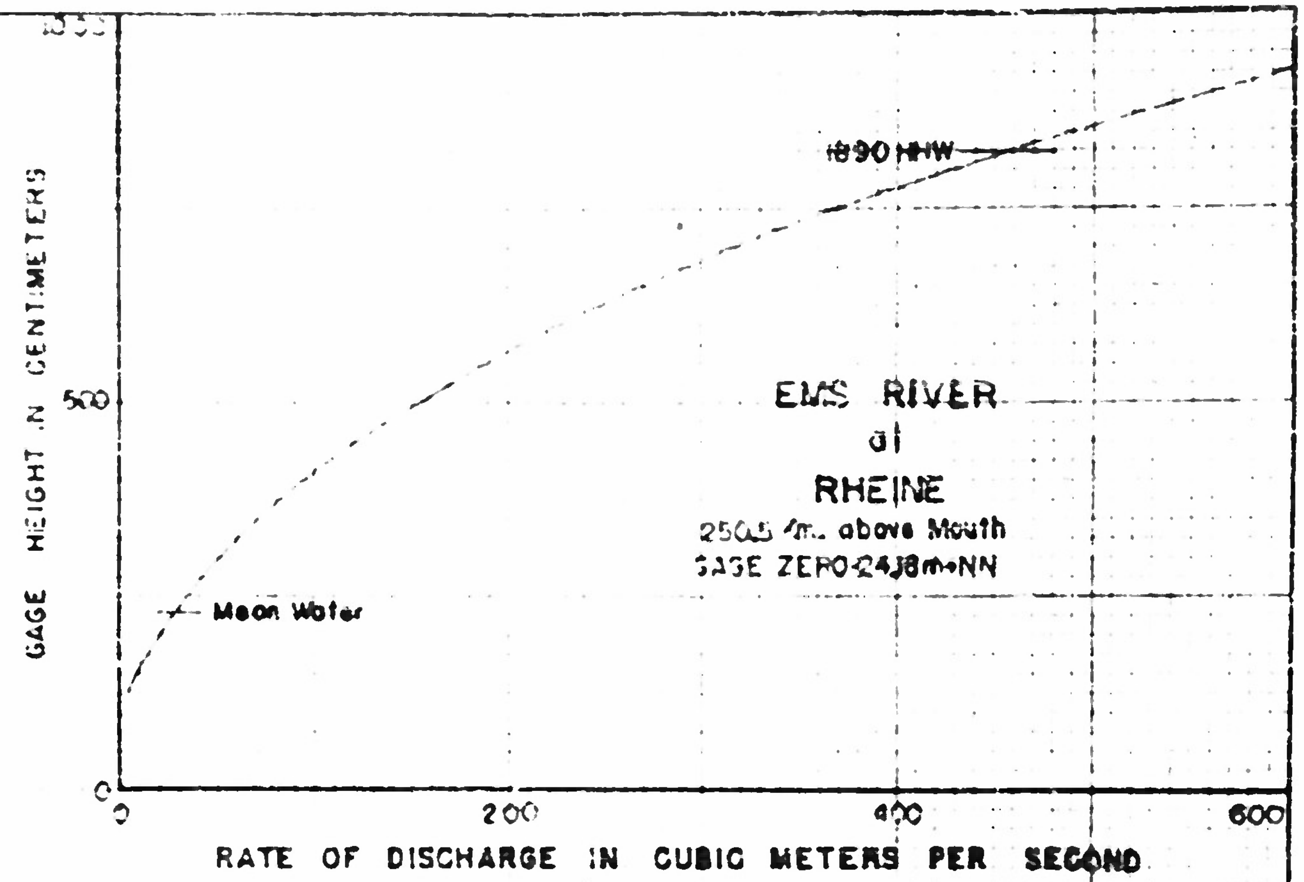
STAGE DURATION CURVES

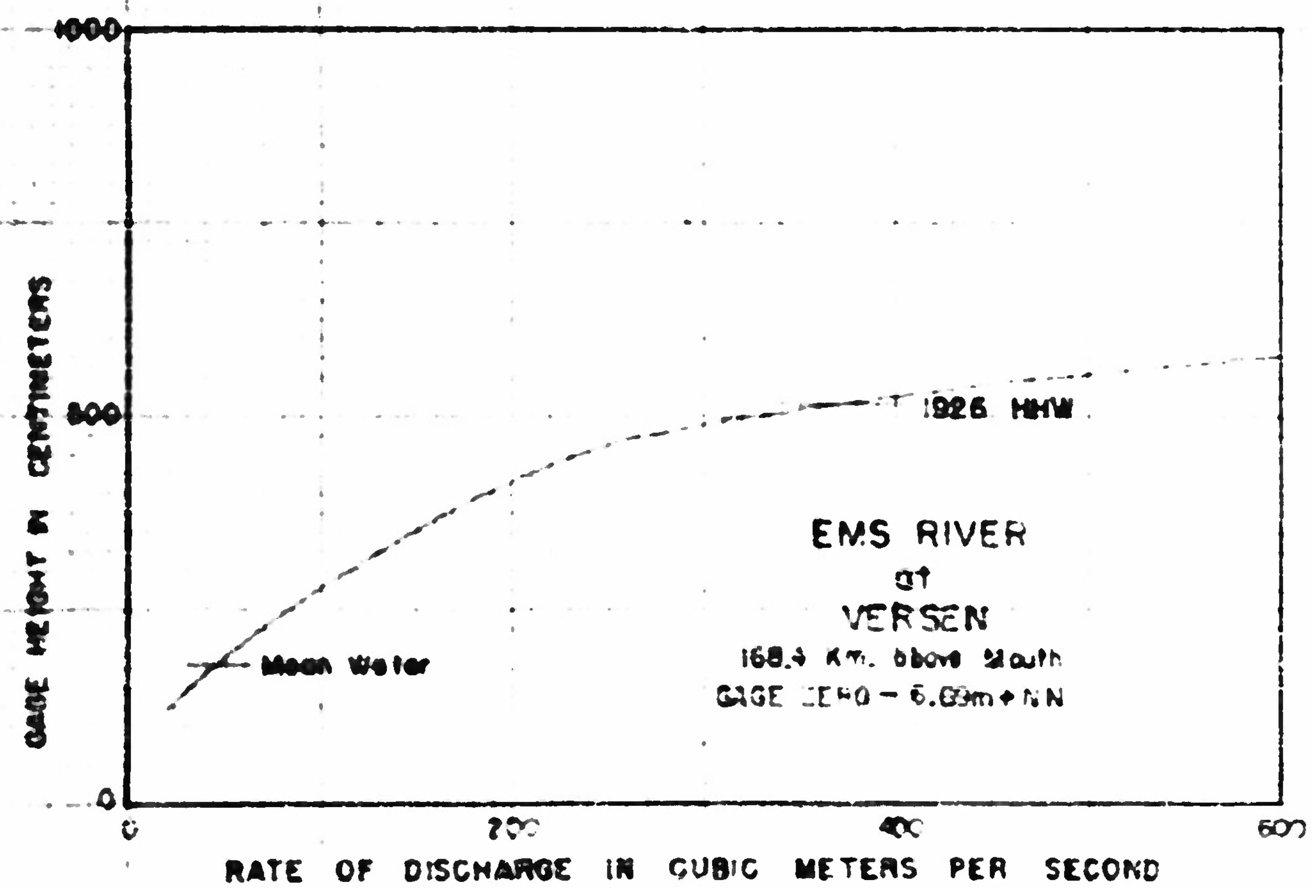
WASHINGTON DISTRICT CORPS OF ENGINEERS

Prepared by ... Date ... 1952
Drawn by ...

RESTRICTED
SECURITY INFORMATION







SOURCE: Rating curves estimated from data in Jahrbuch für die Gewässerkunde des Deutschen Reichs, 1937-38 & in Jahrbuch für die Gewässerkunde Norddeutschlands, 1927-36.

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EMS RIVER
DISCHARGE RATING
CURVES

WASHINGTON DISTRICT CORPS OF ENGINEERS

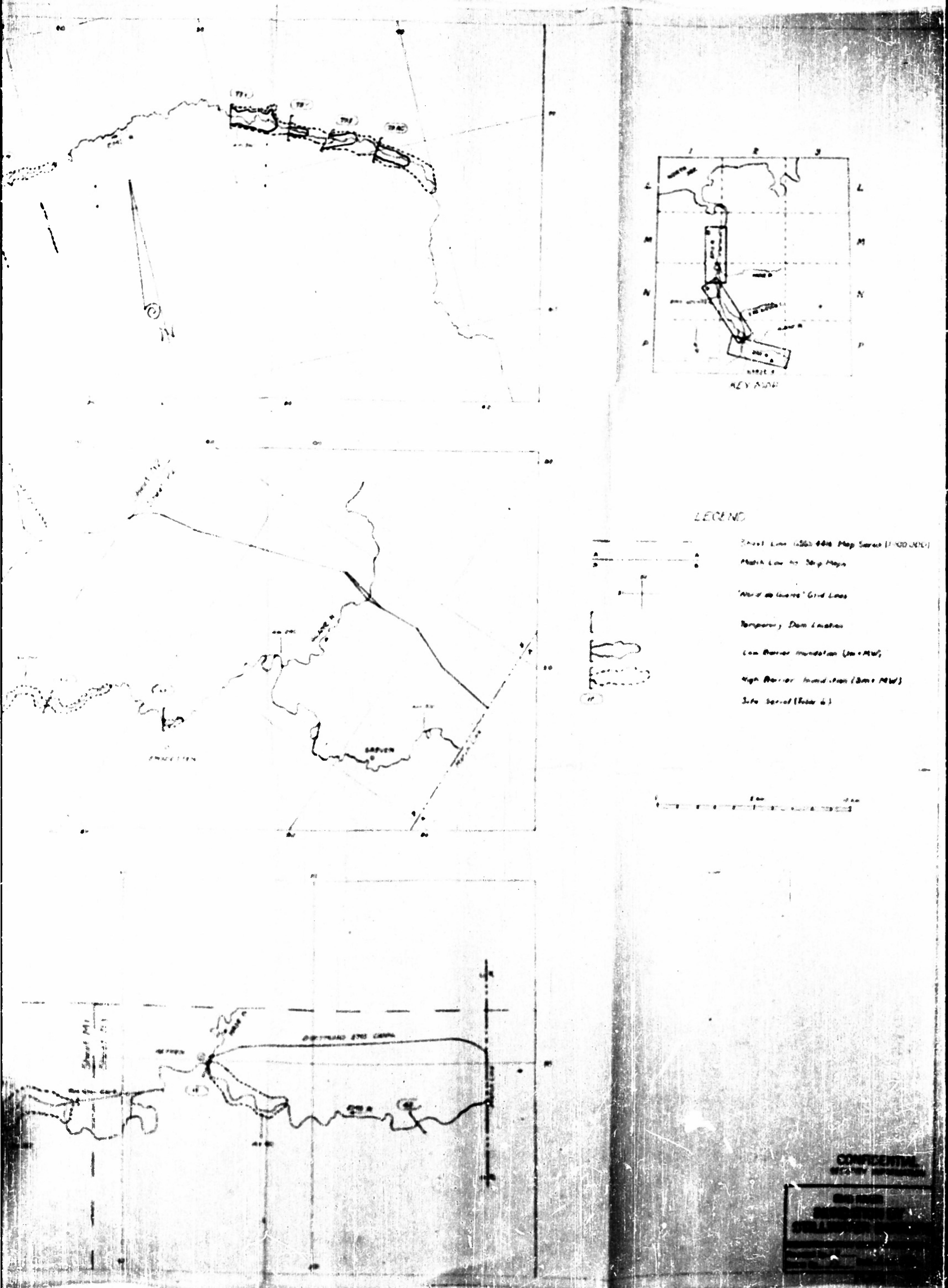
Prepared by F.S.B.

Drawn by J.J.H.

Date AUG. 1952

PLATE


Sheet M2
EMS RIVER
Strip Map A
CONFIDENTIAL
SECURITY INFORMATION
EMS RIVER
Strip Map B
EMS RIVER
Strip Map C
Sheet M1
Sheet N1



KEY MAP
LEGEND
Sheet M1
CONFIDENTIAL

EXHIBIT A

DESCRIPTION OF BRIDGES AND DAMS

EMS RIVER*

*Abstracted and Reproduced from "Report on R. Ems (Second Edition," Part II.) Main Hq. 21 Army Group, December 1944.

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SECURITY INFORMATION

Description of Bridges, Locks, Dams, etc.

N O T E S.

1. Accuracy. The majority of constructional details and measurements have been taken from documentary sources and unless otherwise stated have been checked and supplemented from air photos. Measurements of river widths refer to normal water levels.

2. Crossings not shown on GSGS 4416. A note "Not marked on map" has been included in the remarks column wherever a road or railway bridge exists which does NOT appear on the current edition of the sheet concerned in the GSGS 4416 series. It has not been thought necessary to do so in the case of farm bridges, footbridges and other constructions.

3. Abbreviations.

L. W.	Low water.
M. L. W.	Mean low water
M. H. W.	Mean high water
H. W	High water
H. N. W.	Highest navigable water
m.	metre
N. N.	Normal Null (German land survey datum)

4. Load classification of bridges. The load classification of bridges, as given in this schedule is almost entirely taken from official German ratings by conversion according to the following table:-

GERMAN CLASS	MEANING	BRITISH EQUIVALENT.
(a) Road Bridges.		
I	2 - axled vehicles up to 24 (metric) tons singly and slowly.	class 40 or over.
II	" " " up to 16 tons.	class 24
III	" " " up to 7 tons.	" 12
IV	" " " less than 7 tons	Under class 12.

(b) Railway bridges

M.	max. axle load 25 tons.
E.	" 25 "
G.	" 20 "
H.	" 18 "
J.	" 16 "
K.	" less than 16 tons.

Where the German sources give only a civil rating in tons, usually in the case of weak bridges, this has been recorded in the schedule as e.g. "5 tons". This civil figure is the heaviest safe load in metric tons for 2 axled vehicles without intervals and gives a guide to the strength of the bridge until the military classification can be ascertained. It will be noted that "Class 40" in this schedule includes bridges of greater capacity.

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[illegible] Description of Bridges, Dams, etc. [illegible]

Serial.	Type.	Location & Name.	Map ref	Constructional details.	Overall length.	Width	[illegible]	[illegible]	[illegible]	[illegible]	Remarks
				APPENDIX No. 1.							
4	Weir.	[illegible]	[illegible]	Masonry weir [illegible] long on masonry & concrete foundations. Crest level MH . 21.1[illegible] m. Spill [illegible] ft wide with 12 sluices near right bank. Sill level MH . 1[illegible] m. Fish ladder on right bank.						[illegible]	[illegible]
5	Weir & Lock.	[illegible]	About [illegible] 7[illegible]	Masonry weir 2[illegible] ft long, crest level MH . 2[illegible] m. Spillway [illegible] ft wide with [illegible] sluices near right bank. Sill level MH . 21.[illegible] m. Fish ladder [illegible] ft wide on right bank. Lock [illegible] by 19.[illegible] ft on lock-cut to right of main channel. Fall of [illegible] ft at mean water.						[illegible]	[illegible]
6	Weir & Lock	[illegible]	[illegible]	Low masonry weir 9" deep, [illegible] ft long, [illegible] ft wide built on a natural reef. Lock [illegible] by 19.[illegible] ft on lock-cut to left of main channel. Foot-bridge over lock. Fall of [illegible] ft at MW. Upstream level MH . [illegible] m, downstream MH . [illegible] m at MW.						[illegible]	
[illegible]	Weir	[illegible]	[illegible]	Masonry weir [illegible] ft long, skew at [illegible]° across channel running downstream from right bank. Crown level in centre MH . [illegible] m, ends are slightly higher. Spillway by right bank, width 13.[illegible] ft, sill level MH . [illegible] m. Fish ladder at [illegible]. Mill on millstream on left bank. Mean level upstream MH . [illegible] m, downstream MH . 2[illegible] m.						[illegible]	
7a	Weir	[illegible]	[illegible]	Masonry weir 110.5 ft long. Crown level in centre MH . 35 m. Mean upstream level MH . 35.[illegible] m.						[illegible]	[illegible]
7b	Weir	[illegible]	[illegible]	Weir with 9 sluices across main channel, total width 2[illegible] ft. Weir across millstream on left bank, 6 sluices, total width [illegible] ft. Mill on left bank.						[illegible]	[illegible]
10[illegible]	Road bridge	[illegible]	[illegible]	Two span girder through truss bridge. Length of span over canal 10[illegible] ft. Length of span over R. [illegible] 83 ft.	22[illegible]	6.2	1 x 2.6 1 x 1.8	18	1[illegible] tons ([illegible] tons singly)	Canal [illegible] R. [illegible]	
10[illegible]	Railway bridge	[illegible]	[illegible]	As serial 10[illegible] [illegible].	22[illegible]	6.2	2 x 2.6	19		Canal [illegible] R. [illegible]	Single track.

REPORT ON [illegible] (SECOND EDITION): Description of bridges, ferries, etc. ALL [illegible] IN FEET

Page [illegible]

Serial	Type	Location & name	Map Ref 1/100,000	Constructional Details	Overall Length	Width: Road	Width: Sidewalks	Width: Overall	Load Class	River Width	Depth Max.	Depth Min.	Remarks
1.	Passenger ferry	[illegible]	[illegible] 7385	Probably small passenger ferry from [illegible] on left bank to small harbour of [illegible] on right bank. [illegible] approach road [illegible] from [illegible].						1700	[illegible]	16	
2.	"	[illegible]	774185	Passenger ferry probably running from small harbour in [illegible] down channel 330 yds long by 60 to 100 ft wide to river and across to right bank at 776180 where unmetalled track leads for 600 yds over cuttings to [illegible] - [illegible] rd.						1400	7.5	10	
3.	Rd bridge	[illegible] Ad no 75	[illegible] 796137	Steel plate girder through bridge, 8 spans (179, 204, 206, 2 × 105, 150, 151, 156 ft clear spans left to right). The two centre spans form a swinging bridge on the pier between, which is protected by timber piles. Two right spans and one left span are land spans. Piers and abutments concrete. Just upstream at at 796140 an 8 span steel joist and timber trestle bridge joins the island to the left bank across a 200 ft wide channel.	1676	23	Foot 5 Cycle 3 & 5	38	48 Loads [illegible]	780 at [illegible]	10.5	16	Mine chambers exist. See Fig 1
4.	Vehicle ferry		798135	[illegible] or gravel ramps on both banks. One ferry boat visible.					Unknown	"	"	"	
5.	[illegible]	[illegible] [illegible]	[illegible]	7 span steel through bridge on concrete piers 1115 and abutments. 6 [illegible] girder spans each 166 ft clear span, 1 bascule span of 95½ ft. Double track. Clearance 13.1 ft above [illegible] piers reinforced concrete. Built 19[illegible] - [illegible]	Fixed spans 164 Bascule [illegible]		6		[illegible] tons [illegible] load [illegible]	9.5	7.6	13.[illegible]	[illegible] exist. [illegible]
6.	Vehicle ferry	[illegible]	[illegible]	12 ft rd leads through flood bank each side to metalled ramp. [illegible] cable ferry. Metal boat capacity 150 men or 40 horses or 2 lorries. Length 53½ ft, plus ramps. Laden draught 2 ft. Also one row-boat, capacity 10 men.					20 ton single load 14 ton total load	550	7.[illegible]	1[illegible]	
7.	Passenger ferry	[illegible]	7565	No details available					7 foot 17 ton [illegible]		"	"	
8.	"	[illegible]	[illegible]	15 ft rd leads to metalled ramp each side. [illegible] cable ferry. Metal boat capacity 150 men or 22 horses or 2 lorries. Length 53 ft. Laden draught 2 ft. Also one rowboat, capacity 7 men	[illegible]	"	[illegible]		7 ton single load	[illegible]	"	"	

RESTRICTED
SECURITY INFORMATION

Serial	Type	Location & Name	Map Ref 1:100,000 Sheet	Constructional Details	Overall Length	Width Road	Width Sidewalks	Width Overall	Load Class	River Width	Depth Min	Depth Max	Remarks
7.	Road Br	[illegible]	717[illegible]	Bowstring steel girder central span of 2[illegible] ft clear span with timber deck. [illegible] ft approach land span each side, with metalled roadway. Original [illegible] to north [illegible] at [illegible] south end. Clearance [illegible] ft above [illegible]	407	11	2 x 1	16	[illegible] ton single load	[illegible]	[illegible]	[illegible]	See Plan [illegible]
8.	Road Br	[illegible]	[illegible]	Bridge over old [illegible] which is filled up [illegible]. [illegible] spans (2 x [illegible], 2 x [illegible], 4 x [illegible], 1 x 20.[illegible], 1 x 19.7 clear spans). Steel joists [illegible] in concrete, on reinforced concrete piers.	197	17	2 x 5		At least [illegible]	[illegible]		3	
9.	"	"	[illegible]	Single span steel through girder. Clear span [illegible] ft. Clearance [illegible] ft [illegible]	230	11.8	2 x 4	27.5	[illegible]	[illegible]	[illegible]	[illegible]	Approximately [illegible] as in [illegible] [illegible] ft. See Plan 7
10.	Foot Br	"	[illegible]	[illegible] in two channels with remains of road bridge crossing both over small island. Passable on foot only.						Left [illegible] Right [illegible]			
11.	Road Br	[illegible]	70[illegible]	Single span masonry arch over sidestream	[illegible]	10		12		[illegible]			
12.	Pedestrian Ferry	[illegible]	71[illegible]	[illegible] ramps each side. [illegible] ferry, [illegible] ft long, [illegible] ft wide. Also one rowboat capacity 7 men.					[illegible] tons [illegible] tons axle load	[illegible]	[illegible]	[illegible]	At high river levels landing and [illegible] is difficult
13.	Lock	[illegible] Lock No 17	[illegible]	Length [illegible] ft. Width 50 ft. Depth [illegible] ft, [illegible]. Fall at mean high water 6 [illegible]. Fall at lowest low water 6 ft.						[illegible] at lock gates [illegible]	[illegible]	[illegible]	[illegible] on canal
14.	Road Br	[illegible]	7[illegible]	Steel girder bridge with timber deck. Clear span 112 ft.	130	11[illegible]	2 x 1[illegible]	[illegible]	18	[illegible]	[illegible]	[illegible]	Over canal, [illegible] corresponding bridge over river
15.	Weir	"	71[illegible]	[illegible] sluices each [illegible] ft between masonry piers and abutments. Steel superstructure with timber footwalk. [illegible] of water [illegible] [illegible] ft road approaches. [illegible] [illegible] ft.	2[illegible]			[illegible]		[illegible]	[illegible]	[illegible]	[illegible] on river

[illegible] (SECOND EDITION): Description of Bridges, Dams, etc. ALL MEASUREMENTS IN FEET

Serial	Type	Location & Place	Map Ref 1/250,000	Constructional Details	Overall Length	Road	Width Sidewalks	Overall	Load Class	River Width	Depth	[illegible]	Remarks
[illegible]	Vehicle Ferry	[illegible]	[illegible]	Submerged cable ferry. [illegible] metal punt. Length 46 ft [illegible] width 11 ft. Useful deck space 270 sq ft. Also 1 pontoon capacity 10 men. East approach metalled, west approach sand track unsuitable for laden vehicles.					24 tons (2 ton axle load)	146	6.2	[illegible]	
[illegible]	"	[illegible]	[illegible]	Submerged cable ferry. One punt, length 40½ ft, breadth 14 ft, draught empty 1.3 ft. Useful deck space 307 sq ft. Also 1 pontoon for 10 men. Unmetalled approaches. East approach bad when water is high and hardly negotiable by wheeled vehicles. West approach even worse, impracticable in winter.					[illegible] tons	136	6.2	[illegible]	
[illegible]	Weir	[illegible]	725075	[illegible] steel sluice gates [illegible] ft [illegible]. Clear span of 104 ft between masonry abutments. Head of water 5.9 ft at normal level. Fall towards north.	[illegible]						[illegible]		[illegible]
[illegible]	Lock	[illegible] Lock No 16	[illegible]	Length [illegible] ft, width [illegible], depth [illegible] ft [illegible]. Head of water 5.9 ft at normal level. Fall towards north. Timber [illegible] lock gates.					[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	Road Br	[illegible]	[illegible]	Over downstream end of lock. Steel girder with timber deck, clear span 15 ft. Clearance 13.1 ft.	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		
[illegible]	"	[illegible]	[illegible]	3 span steel girder with timber deck. Clear span 2 x 11, 1 x 213.	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	"	"	Floodbridge [illegible]	Steel, 13 ft clear span	60	17	[illegible]		[illegible]				[illegible]
[illegible]	"	"	"	Steel, 15 ft clear span.	[illegible]	17	"		[illegible]				"
[illegible]	"	[illegible]	[illegible]	Steel through plate-girders. [illegible] left [illegible] ft [illegible] span, right [illegible] ft over river. [illegible]. Clearance [illegible] ft over [illegible].	[illegible]	20	"		"	[illegible]	"	"	[illegible]

[illegible] Description of Bridges, Dams, etc. ALL MEASUREMENTS IN FEET Page 3[illegible]

Serial	Type	Location & Name	Map Ref 1/100,000	Constructional Details	Overall Length	Width Road	Width Sidewalks	Width Overall	Load Class	River Width	Depth LW	Depth HW	Remarks
22.			715793	There is no bridge or ferry here									
23.	Lock	[illegible] Lock No. 1[illegible]	715786	Length 5[illegible] ft, width 80 ft, depth 9.2 ft [illegible]. Fall 7.2 ft at normal level, fall towards north.						30 at Lock gates, 100 upstream and downstream	9.2	9.2	Over [illegible]
24.	[illegible]	•	715799	Over [illegible] end of lock. Steel girder with timber deck. Clear span 67 ft. Clearance 13.1 ft over [illegible].		104	2 x 1.3		10	60	9.2	9.7	Over [illegible]
25.	•	•	715779	Steel girder arch with timber deck. Clear span 112 ft.	130	11.4	2 x 1.4		•	60	9.2	9.7	Over [illegible]
26.	•	•	717[illegible]	•	•	•	•		•	•	•	•	Over [illegible]
27.	•	•	717[illegible]	Steel girder arch with timber deck. Clear span 113 ft. Two [illegible] arch spans each 16 ft.	180	5.4			80 lbs sq ft distributed	60	9.2	9.7	Over [illegible]
28.	Weir	•	716[illegible]	[illegible] steel sluices each of 5.3 ft opening. Clear span of 156 ft between abutments. [illegible] of 7.2 ft at normal level.	167			5.2		166		3.2	Over [illegible]
29.	R[illegible] Br	[illegible]	717[illegible]	Single span steel arch bridge with concrete approaches. Clear span 180 ft. Following flood bridges lie on road from above bridge towards [illegible]:	259	13.4	2 x 3		24	200	9.2	10	
				(a) 7 span reinforced concrete	125	10	2 x 1.4		•				
				(b) [illegible] span reinforced concrete, each span 26 ft	125	•	•		•				
				(c) 7 span reinforced concrete, each span 26 ft	201	•	•		•				
				(d) Single 13 ft span reinforced concrete	13.4	•	•		•				
				(e) 3 span reinforced concrete each span 13 ft.	56	•	•		•				
				(f) 2 span reinforced concrete, each span 13 ft	32	•	•		•				
30.	Vehicle Ferry	[illegible]	709739	Overhead cable ferry, [illegible]. Length 30 ft, width 12 ft, draught empty 1 ft, laden 2 ft. 267 sq ft useful deckspace.					8.8 tons spread load	150	40	40	

REPORT ON R. [illegible] (SECOND EDITION). Description of bridges, dams, etc. [illegible]

Serial	Type	Location & Name	Map Ref 1/[illegible]	Constructional details	Overall Length	Width Road	Width Footpaths	Width Overall	[illegible]
30.	Lock	[illegible] Lock No 16	661710	Length 5[illegible] ft, width 20 ft. Depth [illegible] ft possibly more. Fall 4.9 ft at normal level, fall [illegible]					[illegible] sides, [illegible]
30a.	Road Br	"	"	[illegible] with timber deck, [illegible] 5 ft. Following flood spans [illegible]: (a) 100 yds to right of lock. Steel girder with timber deck, 2 spans of [illegible] ft (b) 120 yds to right of lock steel girder with timber deck, [illegible] span of [illegible] ft, 1 span of [illegible] ft (c) [illegible] yds to right of lock steel girder with timber deck, 1 span of [illegible] ft, 1 span of [illegible] ft.	[illegible] 121	[illegible]	[illegible]		[illegible]
30b.	"	"	[illegible]	Steel girder with timber deck clear span 111.5 ft	[illegible]	[illegible]	[illegible]		[illegible]
31.	Weir	[illegible]	[illegible]	[illegible] steel sluices each of [illegible] ft [illegible] clear span [illegible] ft between abutments. [illegible] of water 4.0 ft at normal level.					[illegible]
32.	Vehicle Ferry	[illegible]	[illegible]	One pontoon [illegible], length 33 ft, width 12.[illegible] ft, height 2.[illegible] ft, draught [illegible] ft. [illegible] capacity. [illegible] may be dismantled.					[illegible]
33.	Road Br	[illegible]	[illegible]	Centre span steel girder span 117 ft [illegible] with timber deck. 3 [illegible] girder spans each side with reinforced concrete deck. Clear spans left 48, 52, 50 ft, right 51, 53, 50 ft. Masonry piers with timber cross-bracing. Clearance 13.1 ft above NWL. [illegible] on right approach at [illegible], 20 span timber bridge (8 x 20.[illegible], 8 x 15.4)	[illegible] 423	Main span 1[illegible]; Side spans 17	2 x [illegible]; 2 x 5		[illegible]
34.	Road Br	[illegible]	[illegible]	2 steel girder spans of 208 ft. 2 reinforced concrete approach spans of 45 ft.	5[illegible]	11.5	2 x 1.6		[illegible]

Serial	Type	Location & Name	Map Ref 1/100,000	Constructional Details	Overall Length	Road	Width Footwalks	Overall	Load Class	River Width	Depth L.W.	Depth H.W.	Remarks
35	Locks	[illegible] Lock No. 13	[illegible]	Two locks in parallel. Old lock 542 by 60ft. New lock 740 by 39.4ft. Depth of old lock 8.6ft. Central island 135ft wide. The new lock is on the right. Fall of 4.9ft towards north at normal level.						About 30 at lock gates [illegible]	[illegible]	8.7	[illegible] canal
35a	Road Bridges	"	"	Bridge over lower end of old and new locks in series. Over new lock 3 span reinf. conc. clear spans 1 x 59ft, [illegible] 18.5ft Over old lock Single 47.6ft span steel girder with timber deck. Joined by 700ft embanked road over island.	96 55.8	10½ 10½	2 x 1.3 2 x 1.3		[illegible] 10	[illegible]	8.2 [illegible]	8.7 8.7	Over canal
36	Road Bridge	[illegible]	670626	Single 114ft steel girder bridge with timber deck	130	11½	2 x 1.3		[illegible]	[illegible]	[illegible]	[illegible]	Over canal
37	Foot Bridge	[illegible]	Sheet 31 [illegible]	Steel girders, 3 spans (2 x 9, 1 x 13 ft) [illegible] and rails, conc. decking	[illegible]	6½			[illegible]	[illegible]	[illegible]	[illegible]	Over canal
38	Road bridge	"	[illegible]	Steel girder with timber roadway 114ft clear span	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
39	Weir	"	572595	Over new cut across meander. Sluices between concrete abutments and central pier. Fall 4.9ft towards north at normal level.									[illegible]
39a	Old weir Road crossing.	[illegible]	665582	Weir of 41 sheet steel sluices of 3.9ft opening each. 164ft between abutments 7 sluices and meander blocked by embankment carrying road.	187			[illegible]		[illegible]		[illegible]	[illegible]
40	Road bridge	[illegible]	676595	Multispan bridge, steel girder across new river cut across meander.	[illegible]			12		210			

8

REPORT ON R. EMS (SECOND EDITION): Description of bridges, dams etc.

ALL MEASUREMENTS IN FEET

Serial	Type	Location & Name	Map ref 1/100,000	Constructional details	Overall length	Width Road	Width sidewalks	Width Overall	Load Class	River Width	Depth L.W.	Depth H.W.	Remarks
41	Road bridge	MEPPEN	681555	6 span steel girder, with timber roadway. Clear spans 4 x 33.5, 2 x 32.4. Probably now replaced by 4 span reinf. conc. bridge scheduled for construction in 1937	210	13.7	1 x 1.6		26	197		3.9	
41a	Road bridge	East MEPPEN	about 681551	On left approach 2.6 kms from bridge serial 41 3 span reinf. conc. clear spans 2 x 50 1 x 51ft	152	19.7	1 x 10.8		at least 40				
41b	"	"	about 679549	On left approach 2.8 kms from bridge serial 41 2 span reinf. conc. clear spans 2 x 16.4	42				26				
42	Vehicle ferry	[illegible]	668527	Roughly metalled approach roads. No boat visible.						180			
43	Road bridge	[illegible]	669644	6 span timber bridge clear spans 2 x 20.7, 5 x 25.9, 1 x 27.3ft.	237	10			Under class 12	206		3.2	
44		[illegible]	679603	No bridge or ferry exists here									
45	Road bridge	[illegible]	686590	5 span reinf. conc. each span 47.6ft	209	12.4	2 x 1.3		16	163		4.9	
46	Weir		691375							125			
47	Road bridge	LINGEN	697350	6 or 7 span ? steel girder and timber bridge	185	10		10		130			
48	Road bridge	" Road bridge	705352	Steel girder, 2 spans of 92ft	216	12.3	2 x 4.3		26	184		2.6	
49	Weir	[illegible]	705306							260			
50	Road & rly bridge	"	711306	3 span steel girder through bridge. Clear spans 536, 68, 197ft. Double track rly. Embanked approaches.	354	rd 13 rly 25	2 x 4.3	29	26	490	8.2	10.3	[illegible] Fit 36
51	Road bridge	[illegible]	725531	4 span reinf. conc. Clear spans 2 x 62, 2 x 69. Embanked approaches ? Masonry abutments on piles.	260	23	1 x 1.3	30	at least 40	213	12.7 channel 3.1	14.? depth 3.9	[illegible]

[illegible] Description of Bridges, Dams etc. [illegible] — All measurements in FEET

Serial	Type	Location & Name	Map ref 1/100,000	Constructional details	Overall length	[illegible]	Width [illegible]	Overall	Load class	River width	[illegible]	[illegible]	Remarks
52	Weir & lock	[illegible]	[illegible]	[illegible]						[illegible]			
53	Road bridge	[illegible]	[illegible]	Steel girder [illegible]. Clear span [illegible]	[illegible]	[illegible]	[illegible]		[illegible]				
54	Weir & lock	[illegible] N of [illegible]	[illegible]	Weir on right channel, [illegible] on left channel. [illegible] 19.5ft width [illegible]									
55	Rly bridge	[illegible]	[illegible]	4 span masonry arch. Clear spans 2 x [illegible], 1 x [illegible], 1 x 26.9ft. Single track railway.	[illegible]					[illegible]			
56	Weir	*	[illegible]	Mill on left bank. Weir across main channel						[illegible]			
56a	Lock	*	795103	Lock on canal cut from 795106 to [illegible]. Length [illegible]ft, width 19.5ft, fall to north of [illegible]						[illegible]			
56b	Lock	*	[illegible]	Ditto. Fall to north of [illegible])						[illegible]			
57	Road bridge	* [illegible] (Fourty 65?)	[illegible]	4 span steel plate girder deck type on masonry piers and abutments. Clear spans 2 x 79.7, 1 x 13.1, 1 x 26.9ft	170	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
58	*	* ([illegible]) ~~[illegible]~~	[illegible]	3 span reinf. conc. arch bridge. Clear spans 66.1, 150.9, 65.2ft.	3[illegible]	[illegible]	[illegible]		*	[illegible]	[illegible]	[illegible]	
59	Railway bridge	*	[illegible]	6 span masonry arch with double track on ballast. Clear spans 6 x [illegible], [illegible]. Embanked approaches.	338	5		50	25 tons axle load (H)	1[illegible]	[illegible]	[illegible]	[illegible]
60 *	Road bridge	[illegible]	Sheet [illegible] [illegible]	7 span reinf. conc. [illegible]. Clear spans [illegible] 50.1, 1 x 135.2. Flood [illegible] 2 x [illegible] ft reinf. conc. beam and slab spans on approach. Built 1935.	251	19.7	2 x 5.3	27.1	at least 60	[illegible]	[illegible]	[illegible]	[illegible] (fitted [illegible] concrete. Plin [illegible] 3? x 3?)
61	? Ferry	*	[illegible]	No bridge. Possibly ferry, but site obscured by trees.						75			
62	Footbridge	N of [illegible]	[illegible]	Single-span light steel girder arch footbridge	150	5		7		65			

* NOT obtained from airphotos.

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SECURITY INFORMATION

REPORT [illegible] Compilation of Bridges, [illegible] etc.

All measurements in feet

Serial	Type	Location	Map Ref 1/50,000	Constructional details	Overall length	Road	Width footways	Overall	Load class	River width	Depth [illegible]	Depth [illegible]	Remarks
63	Road bridge	[illegible]	[illegible]	3 [illegible] girder [illegible] spans 66, 112, [illegible]. Masonry piers and abutments.	[illegible]	16.4	2 x 2.6		at least 40	11?	5.2	7.5	
64	Vehicle ferry	[illegible]	91[illegible]	Cable ferry. Metal [illegible]. (a) Length 30ft, width 10ft, depth 2.6ft, draught empty 1ft. (b) Length 20.3ft, width 5.9ft, depth 2.3ft, capacity 25 men, or 6 horses, or 1 lorry. Also 1 row boat, capacity 6 men.					6 tons	[illegible]	10	[illegible]	Approaches steep & [illegible]
65	Road bridge	[illegible]	[illegible]	3 span reinf. conc. bridge across new river cut. Original meander sealed off and partially dry. No bridge or through route visible, but could probably be crossed by [illegible] dam.	180	[illegible]		46		60			
66	Road bridge	[illegible]	9129.7	Obscured on air photos	40	10		13		50			
67	-	[illegible]	91[illegible]	No bridge or ferry visible									
68	Road bridge	[illegible]	910806	Single span steel girder arch on masonry abutments. Span 155ft	164	15.4	2 x 1.3		at least class 60	76	6.6	5.0	
69	Foot bridge	"	[illegible]	3 span steel girder, spans 60.7, 66.6, 60.7ft	149	9.0			40 lbs/sq ft	[illegible]	6.8	[illegible]	
70	Road bridge	" (Road No. 2??)	917[illegible]	3 span reinf. conc. spans [illegible]ft each. Old demolished bridge just upstream of which 3 piers remain standing on right bank.	312	19.7	2 x 5		at least class 40	[illegible]	6.6	6.5	Site of [illegible] old bridge, piers and both abutments.
70a	Weir	"	919678										
71	Road bridge	[illegible]	[illegible]	Single span steel girder bridge across new river cut. No corresponding bridge across old meander, which is filled in at its upstream end	128	8		12		96 / 5?			Limit of [illegible]
72	-	[illegible]	[illegible]	No bridge or ferry visible.									

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[illegible]

Serial	Type	Location & name	Map Ref.	Constructional details	Overall length	Road width	Width clearance
[illegible]	Road bridge	[illegible]	[illegible]	Single span reinforced concrete arch bridge	160	16	
7[illegible]	Aqueduct	[illegible]	[illegible]	Single span steel trough [illegible] with [illegible] abutments, carrying [illegible] of [illegible] canal, over [illegible]. [illegible] wide [illegible] to [illegible] each side of bridge.	130		
"	"	"	"	Four span masonry aqueduct, [illegible] which formerly carried [illegible] canal. At present empty and water held back by safety gates at each end. Estimated [illegible] above water level, widening to [illegible] at each side. Masonry abutments.	330		
7[illegible]	Road bridge	[illegible]	[illegible]	Single span steel girder arch on masonry abutments. Clear span [illegible]ft.	130	13	
7[illegible]	"	"	[illegible]	Single span [illegible] steel girder	[illegible]		
7[illegible]	Rly bridge	[illegible]	[illegible]	2 span steel plate girder on masonry and reinf. conc. pier [illegible]. Clear spans 2 x 46.3ft	100	16	
7[illegible]	Footbridge	"	[illegible]	[illegible] steel plate girder. Single span [illegible] approaches.	[illegible]		
71a	Road bridge	[illegible]	[illegible]	3 span timber bridge, [illegible]. This bridge was to be replaced in 1939 by a stronger one, but [illegible] this appears not to have been carried out.	[illegible]	[illegible]	
71b	Weir	[illegible]	[illegible]	Weir across both channels. Mill on left bank. (Obscured by trees.)			
71c	Road bridge	" (Para No. 51)	[illegible]	Reinf. conc. beam [illegible] spans, 3 x 21, 4 x 27ft.	176	19.7	2 x [illegible]
				Spans over [illegible]: (a) 2 x 37ft span steel joist and reinf. conc.	31	29	2 x [illegible]
				(b) Reinf. conc. beam and plate, [illegible] spans of 30ft total.	31	[illegible]	2 x [illegible]
				Precise location of these uncertain (b) probably at 016768			

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REPORT ON [illegible] (EDITION), Description of Bridges, [illegible]

ALL MEASUREMENTS IN FEET

Serial	Type	Location & Name	Map ref. 1/100,000	Constructional details	Overall length	Width: Road	Width: Sidewalks	Width: Overall	Lo:. clear	River width	Depth LW	Depth HW	Remarks
[illegible]	Farm bridge	East of [illegible]	053751	? 3 span timber trestle. Approach tracks partially metalled. Unsuitable for MT without repair.	about 60	9		12		about 35	say 1	say 3	
[illegible]	Road bridge	"	111750	Single span steel plate or lattice girder. Approaches metalled. Flood span on each approach	100	10		13	? 12	33	1	2	
[illegible]	Farm bridge	"	116751	3 or 4 span timber trestle driven in rectified course.	85	6		8		35	1	2	
[illegible]	"	"	[illegible]	ditto.	"	"		"		"	"	"	
[illegible]	"	"	[illegible]	ditto	"	"		"		"	"	"	
[illegible]	"	"	[illegible]	ditto	"	"		"		"	"	"	
[illegible]	"	West of [illegible]	[illegible]	ditto	"	"		"		30	"	"	
[illegible]	"	"	[illegible]	[illegible] girder on concrete abutments. Approach tracks unmetalled.	95	9		12		45	"	"	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] span steel plate girder	100	[illegible]		15		30		"	
[illegible]	"	"	[illegible]	[illegible] (i) 3 span [illegible] over river [illegible] (ii) [illegible] (iii) [illegible] There is another footbridge [illegible] footbridge to [illegible]	[illegible]	[illegible]	[illegible]	20	[illegible]	"			See fig. [illegible]
[illegible]	[illegible]	"	[illegible]										
[illegible]	[illegible]	East of [illegible]	[illegible]	? Timber trestle	10[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	2	
[illegible]	"	"	[illegible]	? span timber trestle	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Over tributary
[illegible]		"	[illegible]	? Timber trestle	90	6		8		[illegible]	1	2	

Note: The [illegible] running parallel to the river on the [illegible], with frequent timber [illegible] capacity.

[illegible] D . [illegible] (SECOND EDITION): Description of bridges, dams etc. ALL MEASUREMENTS IN FEET

Serial	Type	Location & name	Map Ref 1/100,000	Constructional details	Overall length	Road	Width sidewalks	Overall	Clear [illegible]	[illegible]	Depth LW	Depth HW	Remarks
7A	Road bridge	SW of [illegible]	[illegible]	3 span RSJ bridge on concrete abutments [illegible] trestles. Spans each 33.5ft. Two 30ft floodbridges on south approach, one on north. Bridge over [illegible]ft wide [illegible] at mill on north approach.	[illegible]	10		15		[illegible]			
7B	Farm bridge	"	[illegible]	[illegible] trestle. Approaches not [illegible].	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	
7C	Road bridge	[illegible]	[illegible]	Probably similar to 7A. [illegible] floodbridge on north, two on south approach.	[illegible]	[illegible]		[illegible]		[illegible]			
7D	[illegible]	SW of [illegible]	[illegible]	[illegible] spans, overhead footwalk.						[illegible]			
7E	Road bridge	"	[illegible]	Reinf. conc. beam and slab. Clear span [illegible]ft approaches [illegible] with [illegible]ft long floodbridge on south approach.	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	
7F	Farm bridge	South of [illegible]	[illegible]	[illegible] bridge on timber trestles	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
7G	"	"	[illegible]	ditto	"			"	"				
7H	Road bridge	"	[illegible]	ditto. Flood bridge on [illegible] south approach.	[illegible]	[illegible]		[illegible]	[illegible]	"	"	"	
7K	Road bridge & sluice	SW of [illegible]	[illegible]	2 span reinf. conc. with sluices on upstream side. Each span 25.[illegible]ft. Bridge over [illegible] on south approach. Reinf. conc. [illegible]ft span. Further small flood bridge to south.	[illegible]	[illegible]	2 x [illegible]		at least [illegible]	[illegible]			
					[illegible]	[illegible]	[illegible]		"	[illegible]	[illegible]	"	
7AA	Farm bridge	"	[illegible]	8 timber trestle	55	8		[illegible]		[illegible]	[illegible]		
7AB	"	South of [illegible]	[illegible]	ditto	"	"		"		"	"	"	
7AC	Road bridge sluice	"	[illegible]	Reinf. conc. beam and slab. 2 spans each 25.5ft. Sluices on upstream side. Timber trestle bridge over millstream on south approach. 3 spans of 15ft	[illegible]	16	6		[illegible]	[illegible]	"		
					[illegible]	[illegible]					"		

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[illegible] Identification of bridges, dams, etc.

ALL MEASUREMENTS IN FEET

Serial	Type	Location & name	Map Ref 1/100,000	Constructional details	Overall Length	Width Road	Width Sidewalks	Width Overall	Load Class	Water width	Depth NW	Depth HW	Remarks
[illegible]	[illegible]	[illegible]	[illegible]	Reinforced concrete beam and slab. Clear span [illegible] ft. No metalled approaches	35.8			13	[illegible]	35	1	2	
[illegible]	″	″	[illegible]	″	″			″	″	″	″	″	
[illegible]	″	″	[illegible]	″	″			″	″	[illegible]	″	″	
[illegible]	[illegible]	″	[illegible]	[illegible] concrete [illegible] and slab. Clear span [illegible] ft. approaches [illegible]. [illegible] reinforced concrete [illegible] and slab, [illegible] span of [illegible] ft.	[illegible]	17	[illegible]		at least [illegible]	[illegible]	[illegible]	[illegible]	
					″	17	[illegible]		″				
[illegible]	[illegible]	″	[illegible]	[illegible] reinforced concrete slab, [illegible] approaches	[illegible]			[illegible]		45	[illegible]	[illegible]	
[illegible]	″	″	[illegible]	″	″			″		″	″	″	
[illegible]	[illegible]	″	[illegible]	[illegible] reinforced concrete slab. [illegible] ft [illegible] track partly metalled	″			″		″	″	″	
[illegible]	[illegible]	[illegible]	[illegible]	Steel plate girder on concrete abutments. [illegible] trestle. Embanked approaches with [illegible]. Composed of [illegible] side by side.	[illegible]			[illegible]	at [illegible]	[illegible]			
[illegible]	[illegible]	″	[illegible]	[illegible] concrete beam and slab. Clear [illegible] ft	[illegible]	[illegible]	2 x 7.5		at least [illegible]	46	1	2	
[illegible]	[illegible]	″	[illegible]	[illegible] arch. [illegible] ft. [illegible] on right bank, [illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	″	[illegible]	Reinforced concrete. [illegible] and over [illegible] and minor roads	[illegible]			70	Probably at least 70	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	Steel plate girder on concrete abutments. [illegible] bridge. Embanked approaches. Single track. Clear span [illegible]	[illegible]	[illegible]			[illegible]	[illegible]	″	″	
[illegible]	[illegible]	″	[illegible]	Rails on concrete abutments. Clear span [illegible] ft	[illegible]		[illegible]			35	1	2	
[illegible]	[illegible]	″ [illegible]	[illegible]	Reinforced concrete arch bridge. 2 [illegible] at [illegible]	[illegible]	25		[illegible]	[illegible]	[illegible]	1	2	

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[illegible] ([illegible])

ALL MEASUREMENTS IN FEET

Page No.

Bridge	Type	Location & Name	Map Ref 1/100,000	Constructional Details	Overall Length	Width	Length [illegible]	Overall	Load Class	[illegible]	Depth	Depth	Remarks
[illegible]	[illegible] Br	[illegible]	354595	Steel plate girder on masonry abutments. Clear span 62 ft.	66.2	16.4	4 x 5.6		at least [illegible]	[illegible]	1	4	
[illegible]	Rly Br	"	464395	3 span steel plate girder on masonry abutments. Clear spans [illegible], 39.4, 27.9 ft.	130.0	11.2			[illegible] ton [illegible] (6)	[illegible]	11	[illegible]	
[illegible]	[illegible] Br	[illegible] of [illegible]	[illegible] 417593	? timber trestle	55	[illegible]		8		[illegible]			
[illegible]	[illegible] Br	"	421590	? reinforced concrete beam and slab	66	12		17		45			
[illegible]	[illegible] Br	"	436[illegible]	? timber trestle or concrete slab. No detailed approaches.	35	6		5		15			
[illegible]	"	"	438576	"	"	"		"		"			
[illegible]	Road Br & [illegible]	West of [illegible]	444577	? reinforced concrete. [illegible]	75	15		22		[illegible]			
[illegible]	[illegible] Br	"	450573	? timber trestle	30	[illegible]		[illegible]		[illegible]			
[illegible]	"	"	458573	? timber trestle. No detailed approaches	45	"		"		"			
[illegible]	Road Br	"	476572	? reinforced concrete slab. Approaches [illegible] but not yet detailed.	60	12		[illegible]		[illegible]			
[illegible]	"	[illegible]	478572	? masonry arch. [illegible] 20 ft [illegible] immediately south	120	12		[illegible]		[illegible]			
[illegible]	Road Br & [illegible]	SW of [illegible]	[illegible]	? reinforced concrete slab with [illegible] upstream side. [illegible]	[illegible]	16		[illegible]		[illegible]			
[illegible]	Road Br	"	4[illegible]	? reinforced concrete slab. [illegible] with sluice, about 100 yds [illegible] downstream. [illegible] right bank is flooded. There is [illegible] across the valley here.	[illegible]	[illegible]		[illegible]		[illegible]			
[illegible]	[illegible] Br	[illegible]	[illegible]	Reinforced concrete slab. Detailed approach left side only. [illegible] at 4[illegible] and upstream at [illegible]	[illegible]	12		15		[illegible]			
[illegible]	"	[illegible]	[illegible]	Reinforced concrete slab. Approaches [illegible] detailed.	[illegible]	12		12		"			
[illegible]	"	"	5[illegible]	Reinforced concrete slab. No approaches.	[illegible]	[illegible]		10		[illegible]			

REPORT ON [illegible] (SECOND EDITION): Description of bridges, dams, etc.

ALL HEIGHTS GIVEN IN FEET

Serial	Type	Location & Name	Map Ref 1/100,000	Constructional Details	Overall Length	Width Road	Width Sidewalks	Width Overall	Load Class	River Width	Depth LW	Depth HW	Remarks
[illegible]	Rly Br	[illegible]	527560	? steel plate girders.	50	10		15		15			
[illegible]	Road Br	"	530563	? reinforced concrete. Approaches roughly detailed.	60	10		14		15			
[illegible]	Sluice	"	536566										
[illegible]	Road Br & Weir	[illegible]	563568	? masonry arch. Mill and weir with mill pool bldgs. Detail obscured by trees.						45			
										20			

Upstream of this serial the river is in several small channels, all under 30 ft in width.

The following serials lie on R. [illegible], and its tributaries, which joins the [illegible] at [illegible] on the right bank.

[illegible]	Foot Br	[illegible]	[illegible]	Probably reinforced concrete slab. Stream rectified into single straight channel. No detailed approaches.	65			11		46			
[illegible]	Road Br	"	[illegible]	Reinforced concrete slab. 2 spans of 15.4 ft.	49.[illegible]	17	1 x 3.3 1 x [illegible]		At least [illegible]	45	2.[illegible]	4.6	
[illegible]	"	"	4[illegible]75	Brick and concrete. Clear span 36 ft.	53.6	20	2 x 3.5		"	22	4.3	3.6	Over [illegible]
[illegible]	Foot Br	"	[illegible]	Reinforced concrete slab. No detailed approaches	60			11		43			
[illegible]	Sluice	"	[illegible]	? concrete with 3 metal gates.									
[illegible]	Road Br	"	[illegible]	Obscured by trees. Approach road 11 ft wide runs to camouflaged building in wood on west bank						27			
										27			
[illegible]	Sluice	"	416[illegible]	? metal.									
										30			

The course has been widened and straightened as far upstream as 41[illegible]. Upstream of this the stream is under 20 ft wide, with tree lined banks.

EXHIBIT B

DESCRIPTION OF WATERCOURSE

AND CONTROL STRUCTURES*

*Abstracted and Translated from "Stromgebiet der Weser und Ems, Einwirklung auf der Wasserfuhrung" (River Basins of the Weser and Ems, Influence of Flow). Military Geography ("Mil-Geo") Training Manual H. Dv. g. 33a, General Staff of German Army, Section 9, Berlin, 1937.

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THE EMS RIVER

I. Description of the watercourse.

Kilometering begins:

1. At the source (Hoevelhof/Senne)

2. At Greven, on the Schoenefliеth Dam (Greven am Wehr Schoenefliеth) (beginning of the official kilometering)

3. At Meppen-Koppe Lock (Meppen-Koppelschlouse) (official river-kilometering in the lower course and tidal area)

Navigation begins at Greven (river-km 0.0) up to river-km 71.8, for vessels of 80-ton capacity, from there up to Hanekenfaehr (river-km 84.4) at MW, for ships up to 150-ton capacity. For further information see "Dortmund-Ems Canal."

The river is often covered with ice up to 30 cm thick in winter; in many winters, only ground ice is formed. Navigation is discontinued on the average of 27 days each year due to ice and high water.

The drainage area of the Ems to Papenburg is 9,500 km^2. From this, the Hase River, the largest Ems tributary (see "Hase River"), contributes 3,125 km^2, and Grosse Aa River 930 km^2.

The precipitation from January 1925-1935 averaged 743 mm (mean average for Germany 690 mm, in North German plains 600 mm), which equals 7,430 m^3 of rain per hectare. The yearly precipitation in the 347,000-hectare area of the Rheine District equals, therefore, 347,000 x 7,430 equals 2,780 mil. m^3 which is 25 percent of the total precipitation in the Ems R. basin. Out of this flow, 1,047 mil. m^3 equals 38 percent, flows into the Ems, and the remaining 62 percent is lost in seepage. Even though summer precipitation of 431 mm exceeds by 40 percent the winter precipitation of 312mm, the discharge volume during summer is only 1/3 of the winter volume, so that winter high water and flooding are considerably greater than summer high water.

To date, the highest winter high water in the Ems (Nov. 1890) was 460 m^3/s, in the Hase at Herzlake, 190 m^3/s (Jan. 1926).

The difference in elevation in the stages between NW and HHW amounted at Rheine to 7.4 m; in the Hase at Herzlake to 4.6 m.

The river is fordable only on the navigable reaches at NW, partly so at MW. Because of moving sand and crumbling banks, regularly used fording places are fixed.

River flats (teinuen) are always passable for horses and motor vehicles.

River bed is fine sand.

Banks: Upper course (up to Rheine) slopes evenly, 1.5 to 2, with the banks rising up over the surrounding land. Middle course (up to Meppen). With the exception of the reach from River-km 0.0 to 72.27, where the banks are mostly steep, the valley is flat and wide. Lower course (up to Papenburg-Halte) partly falling, partly sloping (1:5 to 1:10).

Beginning at Herbrum, the river is tidal.

Depths: 0.85-1.35 m in upper course (excluding dams of 2.1-2.2 m)
2.1-3.1 m in middle course
5 --10 m in lower course, below Papenburg (beginning of Halte) and in the tidal reaches

Water-level width: 10.6-30.0 m im the upper and middle courses; 40-120 m average in the lower course below Papenburg and in tidal reach.

Tributaries:

1. In upper course

   a. Werse (north of Muenster) water-level width at ?? 6-8 m; In some places the mill ponds are 40 m wide and 2-3 m deep.

   b. Muenstersche Aa (km 1.3)

   c. Temmingsmuehlenburg (Km 5.48)

   d. Glane (Km 15.63)

   e. Ems-Dattelner-Muehlenteich (Km 27.34)

   f. Hamelter Bach (Km 45.16)

These streams have a bank width of 2 m, mostly steep, and in reaches are cut in up to 5 m.

2. Middle course

   a. Hase (same as above)

   b. Grosse Aa (8 m wide)

   c. Salinenkanal (Km 51.15) cut in 4 m deep

3. Lower course

10 small streams, 5 of them tidal.

At Haren, the Haren-Rustenbrock-Kanal branches off. It connects by means of the Nord-Sued-Kanal along the Holland border, with the Ems-Vechte-Kanal and the Holland navigation canals.

Continuous dikes exist only in the tidal region.

Dikes exist with crests above flood level.

II. Peacetime regulation and utilization of the flow.

There are no valley dams.

Control structures:

a. In the upper course up to Rheine (River-km 46.6) there are 15 control structures without significance.

b. In the middle course up to Hanekenfaehr (River-km 84.75) there are 4 control structures as follows:

	River km
1. Ems Weir (Emswehr) and Upper Lock (Obenschleuse) Rheine (Map No. 59, Obj. No. 125)	46.6
2. Lower Lock (Unterschleuse) Rheine (Map No. 59, Obj. No. 126)	47.5
3. Bentlage Lock (Map No. 59, Obj. No. 127)	51.7
4. Ems Weir (Emswehr) and Lock, Listrup (Map No. 59, Obj. No. 128)	72.0

Lowering the water stage results in preventing navigation and stopping industrial works (mills and textile factories), otherwise without significance.

c. In the lower course the weirs serve the locks on the Dortmund-Ems-Kanal (see "Dortmund-Ems-Kanal"), as follows:

1.	Hanekenfaehr Weir (Wehr) (Map No. 58, Obj. No. 32)	Middle course River-km 84.75
2.	Versen Weir (Wehr) (Map No. 58, Obj. No. 132	Lower course River-km 10.709
3.	Hilter Weir (Wehr) (Map No. 46, Obj. No. 72b)	Lower course River-km 30.89
4.	Duethe Weir (Wehr) (Map No. 46, Obj. No. 67)	Lower course River-km 40.135
5.	Bollingerfaehr Weir (Wehr) (Map No. 46, Obj. No. 64b)	Lower course River-km 61.1
6.	Herbrum Weir (Wehr) (Map No. 46, Obj. No. 60) .	Lower course River-km 70.438

All without significance.

The Ems-Vechte-Kanal takes from the Weser R. about 2.2 m^3/s of water for navigation and irrigation, which is returned to the Ems by means of the Haren-Rueterbrock-Kanal.

III. Warfare changes in the flow.

By damming the weirs and blocking the bridge openings, the valley reaches in the upper course can be flooded.

In the middle course, blocking the bridges would cause a continuous, artificial water depth of 1.8 m or more.

On the Ems Papenburg, there are no control structures, so that artificial regulation of the flow in this valley is not possible.

The summer dikes between Herbrum and Papenburg have, besides outlet structures (sluice gates and hinged gates that turn for high water stages) also back-wash gates, and can hold water back in reclaimed land for irrigation or flooding purposes. If the outlet works are completely closed, reclaimed land can be drowned out and large valley areas flooded or swamped (see General Map). The duration of the flooding depends on the weather.

In tidal sections, it is possible to keep open the sluice and tide gates during high tide and to close the gates during low tide to retain water, which will flood reclaimed land.

By the opening or blasting of a lock or a weir, a flood wave would be generated, lasting for 24 hours, which would temporarily overflow the next weir, and cause navigation to be stopped above and endanger it temporarily below.

Ems River Basin (Sequence Downstream

Location River km	Sheet No.* Obj. No.	Control St (Name & P	ation Effects Closure Opening Cited Results	Remarks
1	2	3	6	7
Rheine 46.6 km (Kilometering begins at Greven)	59 / 125	Ems Dam (W Rheine Uppe (Oberschle Navigation	eam: Pool elevation be lowered. down of navigation, mill, and several ile factories.	
Rheine 47.5 km	59 / 126	Rheine Lowe (Unterschle Navigation	eam: Pool runs empty. own of navigation ne textile factory.	
NW of Castle, Bentlage 51.7 km	59 / 127	Bentlage Lo (Schleuse) Navigation	eam: Water stage be lowered. own of navigation. n summer of a textile ry.	
NW of Listrup 72.0 km	59 / 128	... am (E and Lock (S Listrup Navigation	eam: Pool elevation be lowered. own navigation.	
At Hanekenfaehr 84.75 km	58 / 32	Hanekenfaeh (Wehr) Navigation	eam: HW causes rise in stage. eam: At MW and NW stage falls. down navigation rtmund-Ems Canal Meppen to Gleesen m the Ems River etrup.	

*General map reference

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Ems River Basin (Sequence Downstream)

DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data: a. Backwater Extent, b. Pool Width, c. Pool Depth, d. Headwater Elev., e. Tailwater Elev.	Lock & Dam Data: a. Lock, b. Dam, c. Bridgeway	Operation Effects: a. Full Closure, b. Full Opening, c. Associated Results	Remarks
1	2	3	4	5	6	7
Rheine 46.6 km (Kilometering begins at [illegible])	59/125	Ems Dam (Wehr) and Rheine Upper Lock (Oberschleuse) Navigation	a. 8.88 km b. 47 m c. 3.7 m d. 30.54 m/NN e. 28.78 m/NN	a. Masonry lock chamber with wooden miter gate. Chamber length 31.3 m; chamber and gate width 5.96 m. b. Masonry fixed dam (wehr) with iron flood gate 7.4 m clear width and 40 m long.	b. Upstream: Pool elevation would be lowered. c. Shut down of navigation, one mill, and several textile factories.	
Rheine 47.5 km	59/126	Rheine Lower Lock (Unterschleuse) Navigation	a. 0.840 km b. 14 m c. 1.4 m d. 28.78 m/NN e. 26.24 m/NN	a. Masonry lock chamber with wooden miter gates. Chamber length 31.3 m; chamber and gate width 5.96 m.	b. Upstream: Pool runs empty. c. Shutdown of navigation and one textile factory.	
NW of Castle, Bentlage 51.7 km	59/127	Bentlage Lock (Schleuse) Navigation	a. 4.15 km b. 21 m c. 1.2 m d. 25.8 m/NN e. 24.98 m/NN	a. Masonry lock chamber with wooden miter gate. Chamber length 31.3 m, chamber and gate width 5.96 m. c. Walkway.	b. Upstream: Water stage would be lowered. c. Shutdown of navigation, and in summer of a textile factory.	
NW of Listrup 72.0 km	59/128	Ems Dam (Emswehr) and Lock (Schleuse) Listrup Navigation	a. 20.21 km b. 45 m c. 1.20 m d. 24.19 m/NN e. 21.97 m/NN	a. Masonry lock chamber with wooden miter gate. Chamber length 29 m, chamber and gate width 5.96 m. b. Masonry fixed dam (wehr) with iron, waste-gate and gravel guard (Griesstaender). Length 64 m, waste-gate width 12.8 m.	b. Upstream: Pool elevation would be lowered. c. Shutdown navigation.	
At Hanekenfaehr [illegible].75 km	56/32	Hanekenfaehr Dam (Wehr) Navigation	a. 2.4 km in Dortmund-Ems Canal 12.4 km in Ems River b. 42 m c. 3.14 m d. 21.57 m/NN e. 18.16 m/NN	b. Fixed dam (wehr) with waste channel. Dam length 68.5 m. Waste channel length 12.6 m. Dam constructed of masonry, waste channel of (Losstaender) and iron valves. Right bank contains a fish ladder.	a. Upstream: HW causes small rise in stage. b. Upstream: At HW and MW water stage falls. c. Shuts down navigation in Dortmund-Ems Canal from Meppen to Gleesen and in the Ems River to Listrup.	

*General map reference

Ems River Basin (Sequence Downstream)

DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data: a. Backwater Extent, b. Pool Width, c. Pool Depth, d. Headwater Elev., e. Tailwater Elev.	Lock & Dam Data: a. Lock, b. Dam, c. Bridgeway	Operation Effects: a. Full Closure, b. Full Opening, c. Associated Results	Remarks
1	2	3	4	5	6	7
W of Versen 19.709 km (Kilometering begins at Meppen	58/192	Versen Dam (Wehr) Navigation	a. 9.4 km b. 42 m c. 2.72 m d. 10.40 m/NN e. 8.20 m/NN	b. Needle weir. Fish ladder on left bank. Length 50.6 m. The locks are located at Huentel.	b. Upstream: Pool from Huentel to Meppen runs empty. Downstream: At sudden opening by blasting, a 1.5 m high wave would be produced, which would run out in about 12 hours.	
W of Hilter 30.09 km	46/72a	Hilter Dam (Wehr) Navigation	a. 11.6 km b. 42 m c. 2.64 m d. 7.50 m/NN e. 5.38 m/NN	b. Needle weir 50.6 m long. Fish ladder on right bank.	a. Without significance. b. Upstream: Pool from Hilter to Huentel runs empty. Downstream: At sudden opening by blasting, a 1.5 m high wave would be produced, which would run out in about 12 hours. c. At low and middle flow navigation would be stopped, endangering vessels in the pool between Hilter and Duethe. Insignificant local inundation.	
W of Lathen 40.135 km	46/67	Duethe Dam (Wehr) Navigation	a. 9.3 km b. 30 m c. 2.64 m d. 6.00 m/NN e. 4.05 m/NN	b. Needle weir 50.6 m long. Fish ladder on right bank.	a.-c. Same as above. Endangering the vessels in the pool between Duethe and Bellingerfaehr.	
At Hande 61.3 km	46/66b	Bellingerfaehr Dam (Wehr) Navigation	a. 11 km b. 42 m c. 2.51 m d. 3.80 m/NN e. 2.00 m/NN	b. Needle weir 50.6 m long.	a.-c. Same as above. Endangering vessels from Bellingerfaehr to Herbrum.	

*General map reference

Ems River Basin (Sequence Downstream) DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data a. Lock b. Dam c. Bridgeway	Operation Affects a. Full Closing b. Full Opening Associated Results	Remarks
1	2	3	4	5	6	7
SW of Herbrum 70.438 km	46 60	Herbrum Dam (Wehr) Navigation	a. 6.6 km b. 42 m c. 2.75 m d. 2.00 m+NN e. 0.40 m+NN	b. Sluice dam, 6 openings 8.5 m each. Iron gate panels, 2.5 m high, upper edge at 2.00 m+NN with movable flap at 2.30 m+NN. Fish ladder on right bank.	Without significance. c. Upstream: Pool from Herbrum to [illegible] [illegible] runs out to free-flowing river stage. Downstream: At sudden opening by blasting, a wave would be created. The wave height and duration would depend on high and low tide. c. Same as above. Endangering [illegible] in the pool from Herbrum to Papenburg.	The dam is located in the tidal area. Normal stage is 2.00 m+NN. Average for the years 1901-1925. Downstream High tide MNW NN+0.61 m MW NN+1.79 m MHW NN+3.28 m Low tide [illegible] NN-0.11 m MW NN+1.14 m MHW NN+3.21 m NNW NN-0.80 m

*Sumseal map reference

DORTMUND-EMS CANAL

I. Description of the Watercourse.

Zero point of the kilometering is at Dortmund.

Up to northwest of Gleesen (Canal-km 138.3) the canal is artificially built up; for a length of about 17 km above Hanekenfaehr Weir (River-km 84.75, Map No. 58, Obj. No. 32) water impounded on the Ems R. is used; after 26 km Seitenkanal (build up "Hanekem Kanal") then flows to River-km 165.8 into Hase R. and for 600 m (from above the mouth), together with this tributary, into the Ems R. From Meppen to the mouth in the Emden river harbor (River-km 269.1), the Ems R. is built up to the Dortmund-Ems Canal.

On the canalized Ems R. between Meppen and Hertrum, there are locks in the canal cut-offs adjacent to weirs (Wehre) on the loops of the Ems R. channel.

From Dortmund up to the branching of the Ems-Weser Canal (Mittelland-Kanal) at km 108.35, only 2 hydraulic structures exist:

	Map No.	Obj. No.	Name	Km.
1)	82b	334	Henrichenburg Boat Elevator (Schiffshebewerk)	15.3
	82b	335b	Henrichenburg High-lift Lock (Schachtschleuse)	14.95
2)	71	146 a-c	Muenster i.W. Locks (3) (Schleusengruppe)	71.3-5

From Bevergern up to the junction with the Ems R. at Canal km 165.6, there are 9 hydraulic structures:

	Map No.	Obj. No.	Name	Km.
3)	59	227	Bevergern Barge Lock (Schleppzugschleuse)	109.3
4)	59	220	Rodde Barge Lock	112.5
5)	59	208	Altenrheine Barge Lock	117.9
6)	59	202	Venhaus Barge Lock	126.6
7)	59	195	Hesselte Barge Lock	134.5
8)	58	33a	Gleesen Barge Lock	137.9
9)	58	33b	Gleesen Small Lock (Kleine Schleuse)	138.0
10)	58	20	Varloh Old & New Locks	158.2
11)	58	18	Teglingen Old & New Locks	164.0
12)	58	16	Meppen Old & New Locks	165.6

Besides these, there are 7 locks in the First Dortmund-Ems Canal in which both old locks:

	Map No.	Obj. No.	Name	Km.
13)	59	230	Borgeshoevede Small Lock	103.6
14)	59	224	Beverrern Small Lock	109.7

are combined into one hydraulic lift, and the 5 locks of the old Haneken-Kanal with the old Geeste Lock (Map No. 58, Obj. No. 21) and Meppen Double Lock (Koppelschleuse) (Map No. 58, Obj. No. 116) are both outside the navigable waterway.

The canalized Ems has 5 hydraulic lifts, with 70 m total drop, as follows:

	Map No.	Obj. No.	Name	Km.
15)	46	75a	Huentel Old Lock	175.6
16)	46	75b	Huentel New Lock	175.6
17)	46	72a	Hilter Lock	187.5
18)	46	67	Duethe Lock	196.7
19)	46	64	Bollingerfaehr Lock	207.7
20)	46	60	Herbrum Lock	214.3

In addition there are two locks at Hanekenfaehr:

	Map No.	Obj. No.	Name	Km.
21)	58	32	Hanekenfaehr New Guard Lock (Sperrschleuse)	140.4
22)	58	[illegible]	Hanekenfaehr Old Guard Lock	139.9

The Oldersum-Emden Side Canal (Seitenkanal)(Canal-Km 260.2-269.0) is 31 m wide and 2,5 m deep and has 2 control structures:

	Map No.	Obj. No.	Name	Km.
23)	31b	[illegible]	Oldersum Sea Lock (Seeschleuse)	-
24)	31a	195	Borssum Sea Lock	

At full opening of the Borssum Sea Lock (Seeschleuse), the harbor water flows in the canal; at full opening of the Oldersum Sea Lock, high and low tide can pass unhindered and over flow the inland, resulting in damage to cultivated fields.

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Between Dortmund and Bergeshoevede (in 1937) the canal was being widened and deepened and one bank or the other reinforced by sheet pilings, 4 m above the river bed, and in 1937, the following reaches had been reinforced; km 1.46-9.3 (left bank), km 15.3-21.05 (both banks), and km 91.8-101.5 (left bank). Further information on the structures or the sheet piling can be found on the general map.

Second route: km 21.06-30.8 at Olfen, km 49.4-50.6 at Senden, km 55.6-56.9 at Amelsbueren and km 108.6-109.7 from Bergeshoevede Lock (Schleuse) up to Bergeshoevede Small Lock (kleine Schleuse).

Weak currents exist only at locks.

The canal is navigable, with exception of infrequent ice blocking, for vessels of 67 m length, 8.2 m wide, and draft of 2.0 m (750 tons). After enlargement is complete: length 80 m, width 9.5 m, draft 2.5 m (1500 tons).

Canal bed, consists of sand or loam; some places of clay or, at Riesenbeck (km 105.7-106.4), of limestone.

Banks are sloped, protected by stone packing or filling, except on reaches with sheet piling (see general map). In limestone reaches, the banks are 9 m high.

Tow-paths are continuous on both sides.

Valley flats (Talauen): In the Dortmund area and further to Datteln, the valley is mostly industrialised, otherwise the land is agricultural. They are passable for horses and motor vehicles. There are many willow trees and ditches.

The streams crossing the canal are :

1) at km 19.8 - Gehlmuehlenbach, cut in deeply
2) at km 19.5 - Mouth of the Datteln-Hamm Canal
3) at Km 21.3 - Mouth of the Wesel-Datteln Canal
4) Northward from there, the canal crosses over the Lippe Valley by means of a high earth dam and canal bridge; the same way over the Stever Valley. At this place, a second route (Fahrt) about 10 km long is being built at Olfen. Each of both routes can be shut off by guard gates on the upper and lower ends.
5) at km 43.4 - Kleuterbach
6) at Km 43.6 - Nonnenbach
7) at km 46.2 - Stever (again)
8) at km 50.9 - Offenbach
9) at km 58.4 - Getterbach
10) at km 67 - below Muenster the canal crosses the Ems Valley in 2 routes, by dam and by canal bridge
11) at km 15.5 - a side canal to Herne branches off

II. Peacetime Regulation and Utilization of the Flow.

To replace the water lost by locks, seepage, and evaporation, replenishing of the canal is necessary.

The level pool 0.0-15.3 is fed out of the lower water through a pumping plant located on the side of the high-lift lock and the ship lock at Henrichenburg. Excess water after intense rainfall goes near the boat elevator (Schiffshebewerk) through a relief structure which may be used to empty the pool at the same time into the lower level pool.

The level pool 15.3-71.5 is fed through the Datteln-Hamm-Kanal, which, in turn, receives water out of the Lippe at Hamm. In addition the pool is fed:

1) through a pumping plant at the Muenster Lock (km 71.5) out of the lower water, which, in turn, is fed from the Weser R. from a pumping plant in Minden
2) through a pumping plant on the Wesel-Datteln Kanal from the Rhein R.
3) through a pumping plant at Olfen (km 23.6) from the Lippe R.

Water consumption of this pool is 10-12 m 3/s.

The following relief structures serve for lowering the water stage:

1) Safety gate at the canal bridge over the Ems R. (km 78.9)
2) At the canal bridge over the Ems (second way)
3) Dam (Wehr) on the Ems R.

The following quantities of water out of the canal are delivered:

1) about 4.4 mil. m^3 per year for the drinking water supply plant for the city of Muenster, i.W.
2) 25,000 m^3 per day for the city electric works of Muenster, i.W. for cooling purposes
3) 70,000 m^3 per year to "Vereinigte Asbest Danco-Wetzel," Dortmund, for cooling and treatment purposes
4) 600,000 m^3 per year to Dortmund "Mill Works (Muehlenwerke)" A.G. for cooling

The west dam of the side canal between Hanekenfaehr and Meppen has outlets which serve for the irrigation of the meadows and lowlands between the side canal (Seitenkanal) and the Ems R. (inundation possible) and for feeding of 600 Morgen (1 Morgen equals 2.12 acres) of fish ponds.

Below [illegible]

1) Outlet on the right bank of the [illegible] for the irrigation of [illegible] (inundation possible [illegible]
2) Outlet on the right bank above [illegible] (with high water, see "Ruhr") [illegible] the Ahlen [illegible]
3) On the right bank of the [illegible] inlet for high water in the [illegible] possible).

III. Further Changes in the [illegible]

The Dortmund-Ems Canal [illegible] the effect of which is increased [illegible] reinforced banks. The water [illegible] the lock gates. The channels [illegible] the flow through the [illegible] location of the [illegible] Muenster [illegible]

Steps for emptying:

1) Closing [illegible] the feeding [illegible]
2) Opening of the release [illegible]

Closure of the emergency [illegible] makes [illegible] of certain [illegible]

The emptying time [illegible] including the [illegible] the emergency gates [illegible] Shortening of the emptying time [illegible] channels on the lock in [illegible] Weser Canal, and Lock VII of [illegible] canal ports, so far as they [illegible] opening the lock [illegible] the water stage is possible [illegible] gates.

The [illegible] navigation [illegible] in Section II [illegible]

The [illegible] Muenster closes [illegible] and the North [illegible] demolition of [illegible] shipping [illegible]

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Canal (Sequence Downstream)

DESCRIPTION OF CONTROL STRUCTURES

Ref No.* 33. No.	Control Structure (Name & Purpose)	Pool Data: a. Backwater Extent b. Pool Width c. Pool Depth	d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data: a. Lock b. Dam c. Bridgeway	Operati[...]: a. Full Clo[...] b. Full Ope[...] c. Associat[...]
2	3	4		5	6
82b 35b	Henrichenburg High-lift Lock (Schachtschleuse) Navigation in canal pool km 0.0-14.95	a. 14.950 km b. 30 m c. max. 3 m d. 69.84 m/NN e. 56.15 m/NN		a. Masonry lock with water-saving basin. Chamber length 95 m. Chamber and gate width 10 m. c. Roadway 7.5 m (heavy vehicles). Walkway 2x1.5 m. Load-steam roller, 24 ton.	a. None b. Upstream runs o[...] (km 13.[...] to safe[...] 1.954 [...] km 0.0. Downstr[...] opening ately [...] would b[...] signifi[...] water's c. At a) N[...] routed richenb[...] ter (Se[...] At b) D[...] Werke [...] lag wa[...]
Linden-[...] of Henrichenburg 15.3 km	Henrichenburg Boat Elevator (Schiffshebewerk) Navigation in the canal pool km 0.0-15.3	a. 15.3 km b. 30 m c. max. 3 m d. 69.89 m/NN e. 56.15 m/NN		a. Boat [...] with 5 floats. Steel construction. Trough length 68 m. Trough and gate width 8.6 m. c. Roadway 4 m (heavy vehicles) Walkway 2x0.4 m.	a. Withou[...] b.-c. Sa[...] (from Navig[...] High-[...] (Sch[...]

*General map reference

DESCRIPTION OF CONTROL STRUCTURES

	Pool Data a. Backwater Extent d. Headwater Elev. b. Pool Width e. Tailwater Elev. c. Pool Depth	Lock & Dam Data a. Lock b. Dam c. Bridgeway	Operation Effects a. Full Closure b. Full Opening c. Associated Results	Remarks
	4	5	6	7
4 d- to s	a. 56.3 km on the Dortmund-Ems canal 11 km on the Herne Branch Canal 40 km on the Lippe Canal. Datteln-Hamm. d. 56.15 m/NN e. 50 m/NN	a. Masonry storage lock (Sparschleuse). Chamber length 165 m. Chamber and gate width 10 m. c. Roadway 3.5 m (light vehicles). Walkway 2x0.5 m. Concentrated load 10 tons, 400 kg/m^2.	a. Without influence. b. Upstream: Canal pool runs empty up to safety gate at km 29.497 or 21.585. Failure of the safety gate would empty pool up to km 15.3, including the branch canal to Herne & Lippe Canals. Downstream: At sudden opening of the gate, moderately large flood wave would be created. The effect could be increased by simultaneous opening of locks 1 and 3.	Destruction: An easy way is through the upper or lower gate. Navigation would not be stopped; only by simultaneous shutting off of locks 1 and 3 in Muenster. Destruction of the upper and lower gates; emptying of the canal pool and stopping of navigation. Destruction of the water-saving basin will not eliminate the utility of the lock.
3 :	Same as Lock 2 Muenster	a. Masonry, long-tow barge (Schleppzug-Sparschleuse) lock with water-storage basin. Chamber length 225 m. Chamber and gate width 12 m. c. Roadway 3.5 m (light vehicles). Walkway 2x0.5 m Class II, 10-ton, 400 Kg/m^2 concentrated load.	a.-c. Same as Lock 2 Muenster.	Destruction: Same as Lock 2 Muenster.
1)	Same as above	a. Masonry, water-storage basin. Chamber length 67 m. Chamber and gate width 8.6 m. c. Roadway and walkway same as above.	a.-c. Same as above.	Destruction: Same as Lock 2 Muenster.

Dortmund-Ems Canal (Sequence Downstream)

DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data a. Lock b. Dam c. Bridgeway	Operation Effects a. Full Closure b. Full Opening c. Associated Results	Remarks
1	2	3	4	5	6	7
Bergeshoevede 108.6 km	59/230	Bergeshoevede Small Lock (Kleine Schleuse) Navigation	a. 37.1 km 174.4 km in Ems-Weser Canal b. 30-34.25 m c. max. 3-3.2 m d. 50.0 m/NN e. 45.7 m/NN	a. Masonry lock chamber with iron miter gate. Chamber length 67 m. Chamber and gate width 8.6 m. c. Roadway 4.5 m. Class III, 10 tons.	a. Little b. Canal bed runs dry in entire reach upstream when the guard gates are not locked. Downstream, by sudden opening (blasting), a strong wave is created. c. The Bevergern Little Lock (kleine schleuse) and the side dams of the canal would be flooded by the closure of the above gates. Bevergener Lowlands (Niederung) would be flooded and navigation stopped.	Destruction: Navigation to [illegible] and Emden would stop. Col. 6c. In case of war, a needle valve should be installed.
N of Bevergern 109.3 km	59/227	Bevergern Long-tow Barge Lock (Schleppzugschleuse) Navigation	a. 37.0 km 174.4 km in Ems-Weser Canal b. 30-34.25 m c. max. 3-3.2 m d. 50.0 m/NN e. 41.7 m/NN	a. Masonry, water-storage basin. Upper gate: iron hinge gate. Lower gate: iron miter gate. Chamber length 165 m. Chamber and gate width 10 m. c. Roadway 5 m (heavy vehicles) Walkway 2x1 m. Class III, 24 tons.	a.-c. Same as above. to c. Flooding of Rodde Lock and the canal side dams (Seitendaemme).	Destruction: Same as above.
N of Bevergern 109.7 km	59/224	Bevergern Small Lock (Kleine Schleuse) Navigation	a. 1.03 km b. 30 m c. max. 3 m d. 45.7 m/NN e. 41.7 m/NN	a. Masonry lock chamber with iron miter gate. Chamber length 67 m. Chamber and gate width 8.6 m. c. Roadway 1.5 m. (pedestrian) Schrammbord 2x0.35 m.	a. Conditions unchanged. b. Canal bed fails. c. Rodde Lock and Gate would be flooded.	Destruction. Navigation stopped between Bergeshoevede and Emden. to 6c. In event of war, install needle valve.

*General map reference

Dortmund-Ems Canal (Sequence Downstream)

DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data: a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data: a. Lock b. Dam c. Bridgeway	Operation Effects: a. Full Closure b. Full Opening c. Associated Results	Remarks
1	2	3	4	5	6	7
E of [illegible] 112.5 km	56 / 220	Rodde Long-tow Barge Lock (Schleppzugschleuse) Navigation	a. 3.002 km b. 30 m c. max. 3 m d. 41.70 m/NN e. 37.90 m/NN	a. Masonry lock chamber. Upper gate: iron hinge gate. Lower gate: iron miter gate. Chamber length 165 m. Chamber and gate width 10 m. c. Roadway 4.30 m (heavy vehicles). Class III, 10 tons.	a. None. b. By blasting the gate in the lower gate the Altenrheine Lock would be flooded. c. For defense, needle valve should be installed.	
Altenrheine 117.9 km	59 / 208	Altenrheine Long-tow Barge Lock (Schleppzugschleuse) Navigation	a. 5.176 km b. 30 m c. max 3 m. d. 37.90 m/NN e. 34.30 m/NN	a. Masonry lock chamber. Upper gate: iron hinge gate. Lower gate: iron miter gate. Chamber length 165 m. Chamber and gate width 10 m. c. Roadway 4.11 m (heavy vehicles). Class III, 10 tons.	a.-c. Same as above. Floods Venhaus Lock.	
About 3 km NW of Venhaus 120.8 km	56 / 202	Venhaus Long-tow Barge Lock (Schleppzugschleuse) Navigation	a. 8.551 km b. 30 m c. max. 3 m d. 34.30 m/NN e. 30.80 m/NN	a. Masonry lock, chamber. Upper gate: iron hinge gate. Lower gate: iron miter gate. Chamber length 165 m. Chamber and gate width 10 m. c. Roadway 4.11 m (heavy vehicles). Class III, 10 tons.	a.-c. Same as above. Floods Hesselte Lock.	
About 2 km NW of Hesselte 130.5 km	59 / 195	Hesselte Long-tow Barge Lock (Schleppzugschleuse) Navigation	a. 7.628 km b. 30 m c. max. 3 m d. 30.80 m/NN e. 27.44 m/NN	a. Masonry lock chamber. Upper gate: iron hinge gate. Lower gate: iron miter gate. Chamber length 165 m. Chamber and gate width 10 m. c. Roadway 4.11 m (heavy vehicles). Class III, 10 tons.	a.-c. Same as above. Floods Gleesen Lock.	

*General map reference

Dortmund-Ems Canal (Sequence Downstream)

DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data: a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data: a. Lock b. Dam c. Bridgeway	Operation Effects: a. Full Closure b. Full Opening c. Associated Results	Remarks
1	2	3	4	5	6	7
NE of Elbergen 137.9 km	58/33a	Gleesen Long-tow Barge Lock (Schleppzugschleuse) Navigation	a. 3.187 km b. 30 m c. max. 3 m d. 27.44 m/NN e. 21.57 m/NN	a. Masonry lock chamber. Upper gate: iron hinge gate. Lower gate: iron miter gate. Chamber length 165 m. Chamber and gate width 10 m. c. Roadway 4.15 m (heavy vehicles). Class III, 10 tons.	a. None b. Downstream: Blasting of the gate creates a wave which runs out in the Ems R. c. Navigation would stop. Ems River would rise. Needle valves should be installed.	Navigation can be routed through Gleesen small lock (Kleine Schleuse).
NE of Elbergen 138.0 km	58/33b	Gleesen small lock (Kleine schleuse) Navigation	a. 3.416 km b. 30 m c. max. 3 m d. 27.44 m/NN e. 21.57 m/NN	a. Masonry, storage chamber, with iron miter gates. Chamber length 67 m. Chamber and gate width 8.6 m. c. Roadway 4.34 m (heavy vehicles). Class III, 10 tons.	a.-c. Same as above.	Same as above.
At Hanekenfaehr 139.96 km	58/125	Hanekenfaehr Old Guard-Lock (Alte Sperrschleuse) Navigation	a. 2.4 km 12.4 km in the Ems River b. 42 m c. max. 3.14 m d. 21.57-23.45 m/NN e. 21.57 m/NN	a. Lock with masonry head and sloping side walls. Chamber length 45 m, width 6.1 m. Gate width 5.96 c. Walkway 4 m.	a. Little significance b. At NW and MW, none. At HW in the Ems River, the pool from Hanekenfaehr to Verloh is raised. c. At HW in the Ems River and blasting of the gates a wave about 1 m high would be created, endangering navigation, inundating some land, and may cause some dams to break.	
At Hanekenfaehr 140.4 km	58/32	Hanekenfaehr New Guard-Lock (Neue Sperrschleuse) Navigation	Same as above	a. Masonry head and sloping side walls. Chamber length 165 m. Chamber and gate width 10 m. c. Walkway 1.8 m.	a.-c. Same as above.	

*General map reference

Dortmund-Ems Canal (Sequence Downstream)

DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data a. Lock b. Dam c. Bridgeway	Operation Effects a. Full Closure b. Full Opening c. Associated Results	Remarks
1	2	3	4	5	6	7
At Geeste EW Station 155.42 km	58 21	Geeste Old Lock (Alte Schleuse) Formerly for navigation of the Ems River. Not in operation.	a. 17.8 km b. 30 m c. max. 2.5 m d. 21.57 m/NN e. 19.21 m/NN	a. Masonry storage lock. Shut off at upper head by a wall. Chamber length 28.5 m. Chamber and gate width 5.96 m. c. Roadway 4.34 m.	a.-c. Same as above	Lock is not operative for navigation.
E of Varloh 158.2 km	58 29	Varloh New Lock (Neue Schleuse) Navigation	a. 17.8 km b. 42 m c. max. 2.5 m d. 21.57 m/NN e. 17.90 m/NN	a. Masonry lock. Iron miter gates. Chamber length 165 m. Chamber and gate width 10 m. c. Roadway 4.34 m.	a.-b. Same as above c. Blasting of the gates will produce a wave 2.5 m high, endangering navigation and flooding adjacent land.	
E of Varloh 158.2 km	58 20	Varloh Old Lock (Alte Schleuse) Navigation	a. 2.8 km b. 18 m c. max. 2 m d. 19.21 m/NN e. 17.90 m/NN	a. Masonry lock with upper head shut off by a wall. Chamber length 28.5 m. Chamber and gate width 5.96 m. c. Roadway 4.34 m.	a.-c. No special significance.	Lock is not operative for navigation.
S of Meppen 164.0 km	58 18	Teglingen New Lock (Neue Schleuse) Navigation	a. 5.7 km b. 30 m c. max. 2.5 m d. 17.90 m/NN e. 14.60 m/NN	a. Masonry lock with iron miter gates. Chamber length 165 m, width 10 m. Gate width 10 m. c. Roadway 2.1 m Walkway 2x0.4 m.	a.-b. Same as above. c. By blasting, a wave 2 m high would be created, endangering navigation, flooding Meppen Lock and the old Koppel Lock (Koppelschleuse) in Old Haneken Canal. Danger of dams breaking.	

*General map reference

Dortmund-Ems Canal (Sequence Downstream)

DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data: a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data: a. Lock b. Dam c. Bridgeway	Operation Effects: a. Full Closure b. Full Opening c. Associated Results	Remarks
1	2	3	4	5	5	7
At Meppen 164.0 km	22 18	Tegliagen Old Lock (Alte Schleuse) Navigation	a. 5.7 km b. 30 m c. max. 2.5 m d. 17.90 m/NN e. 14.60 m/NN	a. Masonry lock with wooden miter gates. Chamber length 28.5 m. Chamber and gate width 5.96 m c. Roadway 2.15 m Walkway 2x0.4 m	a.-b. Same as Hanekenfaehr Guard Lock (Sperrschleuse) (km 139.96) and Tegliagen New Lock (Neue Schleuse). c. Blasting will create wave 2 m high, endangering navigation, flooding Meppen Lock, and the old Double-Lock (Koppelschleuse) in the Old Hanekon Canal. Danger of dams breaking below Tegliagen.	
At Meppen 165.5 km	22 16	Meppen Old Lock (Alte Schleuse) Navigation	a. 1.7 km b. 30 m c. max. 2.5 m d. 14.70 m/NN e. 10.40 m/NN	a. Masonry lock. Upper end, iron hinge gate. Lower end, iron miter gate. Chamber length 100 m. Chamber and gate width 10 m. c. Roadway 2 m Walkway 2x0.3 m	a.-b. No significance. c. Blasting will cause the pool from Meppen to Tegliagen to run dry. Navigation would stop.	
At Meppen 165.6 km	58 16	Meppen New Lock (Neue Schleuse) Navigation	a. 1.7 km b. 30 m c. max. 2.5 m d. 14.70 m/NN e. 10.40 m/NN	a. Masonry lock. Upper end, hinge gate. Lower end, miter gate. Chamber length 165 m. Chamber and gate width 10 m. c. Roadway 2 m Walkway 2x0.3 m	a.-c. Same as above. The discharged wave runs out in a short time in the Ems River.	
E of Meppen 165.5 km	58 116	Meppen Double Lock (Koppelschleuse) Navigation	a. 1.7 km b.-e. Same as Meppen New Lock above.	a. Masonry lock 3 wood miter gates. Chamber length 2x28.5 m. Chamber and gate width 5.96 m	a.-c. Same as Meppen Lock above.	
Hunteler-brook (at Haren) 175.6 km	46 75a	Huntel Old Lock (Alte Schleuse) Navigation	a. 10.1 km b. 30 m c. max. 2.72-3.03 m d. 10.40 m/NN e. 7.50 m/NN	a. Masonry heads, sloped chamber walls. Chamber length 165 m. Chamber and gate width 10 m c. Roadway 3.2 m Walkway 2x0.4 m	a. No significance. b. Downstream: Blasting creates wave 2 m high, which runs out in about 12 hours. c. At NW and MW, navigation stopped. Temporary and insignificant local flooding.	

*General map reference

Dortmund-Ems Canal (Sequence Downstream) — DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data a. Headwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data a. Lock b. Dam c. Bridgeway	Operation Effects a. Full Closure b. Full Opening c. Associated Results	Remarks
1	2	3	4	5	6	7
Huentelerbrock (at Haren) 175.6 km	56/75b	Huentel New Lock (Neue Schleuse) Navigation	a. 10.1 km b.-e. Same as Huentel Old Lock above.	a. Masonry, iron miter gates. Chamber length 225 m. Chamber and gate width 12 m. c. Roadway 3.2 m Walkway 2x0.4 m	a.-c. Same as Huentel Old Lock above.	
NE of Duethe 196.7 km	56/67	Duethe Lock (Schleuse) Navigation	a. 9.3 km b. 30 m c. max. 2.64 m d. 6.00 m/NN e. 3.80 m/NN	a. Masonry heads. Sloping chamber walls. Iron miter gates. Chamber length 165 m. Chamber and gate width 10 m. c. Roadway 3.2 m Walkway 2x0.4 m	a. No significance. b. Downstream: Blasting will create a wave 1.5 m high, which runs out in about 12 hours. c. Through navigation stopped. At HW and NW, endangers vessels in the pool from Duethe to Bollingerfaehr. Insignificant local flooding.	
At Heede 207.7 km	56/64	Bollingerfaehr Lock (Schleuse) Navigation	a. 11 km b. 30 m c. max. 2.51 m d. 3.80 m/NN e. 2.00 m/NN	a. Masonry heads. Sloping chamber walls. Chamber length 165 m. Chamber and gate width 10 m. c. Roadway 2 m Walkway 2x0.3 m	a.-c. Same as above.	
E of Herbrum 214.30 km	56/60	Herbrum Lock (Schleuse) Navigation	a. 6.6 km b. 30 m c. max. 2.75 m d. 2.00 m/NN e. 0.15 m/NN	a. Masonry heads. Sloping chamber walls. Upper end, iron miter gate. Lower end, iron, vertical-lift gate, electrically operated. Chamber length 201 m. Chamber and gate width 10 m (lower gate 12)	a. No significance. b. Upstream: Pool from Herbrum to Bollingerfaehr runs empty Downstream: Sudden opening by blasting creates a wave of varying height depending on high or low tide. c. Through navigation stopped. Insignificant local flooding.	
S of Oldersum 260.2 km	31b/31a	Oldersum Sealock (Seeschleuse) Navigation Drainage	a. The Ems River in tide region. d. 5.18 m/NN at high tide. e. -0.95 m/NN at low tide.	a. Chamber length 100 m, width 12 m. Gate width 10 m. c. Roadway 5 m	a. None b. Inundation of lowlands. c. Damage to cultivated land. Endangers wharves on inland harbor. 2 pairs of double gates for safety.	

*General map reference

Dortmund-Ems Canal (Sequence Downstream)

DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data: a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data: a. Lock b. Dam c. Bridgeway	Operation Effects: a. Full Closure b. Full Opening c. Associated Results	Remarks
1	2	3	4	5	6	7
Borssum 269.0 km	31a 195	Borssum Lock (Schleuse) Navigation	a. Area of inland harbor. 148 hectares e. Old Inner Harbor 5 m Navigation stage 7 m Industrial Harbor 9 m New Harbor 10.5 m d.-e. Harbor 1.10 m/NN Canal 0.95 m/NN	a. Chamber length 100 m Chamber and gate width 10 m c. Roadway 3.6 m, single track RR bridge	a. Canal and harbor, none. b. Canal Banks: Harbor water flows in canal located at sea level. Harbor Banks: Water stage lowered in Emden inland harbor. c. Damage to cultivated land. Endangers wharves on the inland harbor. Protection: Install needle valves on both heads.	

*General map reference

RESTRICTED
SECURITY INFORMATION

EMS RIVER, LEFT-SIDE CANALS
(Linksemsische Kanaele)

I. Description of the Watercourse.

The following canals belong to this system:

a. Ems-Vechte Canal, 21.96 km long, with connecting canal to the upper Vechte R., 0.8 km long.

b. South-North Canal, 45.60 km long.

c. Schoeninghsdorf-Hoogeveen Canal, 2.65 km long.

d. Haren-Ruetenbrock Canal, 13.50 km long.

e. Piccardie-Coevorden Canal, 23.50 km long.

f. Nordhorn-Almelo Canal, 4.20 km long.

The canals a) - e) belong to the Ems R. Basin; canal f) belongs to the Vechte R. Basin.

a[1]) Ems-Vechte Canal:

Branches out of the Ems at Hanekenfaehr Lock and joins the North-South Canal at Nordhorn.

The canal, which breaks through between the Ems and Vechte watersheds, is located in the valley of these rivers between dams, otherwise the entire length is in a 7-m deep cut.

Therefore, there is a large amount of ground-water flow and slight ice formation.

Canal bottom: Sand, with stretches of clay.

Water-level width: 16 m.

Depth: 2.1 m.

2 control structures, as follows:

Map No.	Obj. No.	Name	Canal km.
58	45	Ems Lock (Emsschleuse) at Hanekenfaehr, mouth in the Dortmund-Ems Canal	0.06
58	152a	Lock at Nordhorn-Frenswegen (mouth in the lower Vechte)	21.3

RESTRICTED
SECURITY INFORMATION

a2) Besides 1 lock in the Verbindungs Canal with the upper Vechte:

Map No.	Obj. No.	Name	Canal km.
58	129b	Nordhorn Lock	0.7

b) **South-North Canal:**

The canal is located between dams. In its southern reach, it flows in the Vechte and Lee valleys, crossing in the northern reach (below Lock IV, Old Piccardie, canal-km 10.9, up to a few km above the mouth in the Haren-Ruetenbrook Canal), the large moors located along the Netherlands border.

Canal bottom: In the southern reach, sandy; in the northern reach, sandy and peat.

Water-level width: 12-16 m.

Depth: 1.8 -2.1 m.

7 control structures, as follows:

Map No.	Obj. No.	Name	Canal km.
58	61a	Lock I at Bakelde	1.1
58	62a	Lock II at Nordhorner Wiesen	3.8
58	64a	Lock III at Hohenkoerben-Wietmarschen	7.4
58	65a	Lock IV at Alte Piccardie	10.9
58	81a	Lock V at Hebelermoor	34.9
46	203a	Lock VI at Fehndorf	38.6
46	209a	Lock VII at Ruetenbrock-Gosebrook	44.6

c) Schoeninghsdorf-Hoogeveen Canal:

Canal bottom: Sandy.

Water-level width: 16 m.

Depth: 2.1 m.

1 lock as follows:

Map No.	Obj. No.	Name	Canal km.
58	153a	Guard Lock (Sperrschleuse) on the German-Netherlands border	2.7

d) Haren-Ruetenbrocker Canal:

Canal bottom: Sandy.

Water-level width: 16 m.

Depth: 2.1 m.

4 control structures, as follows:

Map No.	Obj. No.	Name	Canal km.
46	208a	Lock I at Haren	0.1
46	216a	Lock II at Altharen-Brikn	6.8
46	219	Lock III at Ruetenbrock (Hintern Busch)	10.9
46	223a	Guard Lock (Sperrschleuse) on the German-Netherlands border	13.4

e) Piccardie-Coevorden Canal:

Canal bottom: Sandy.

Water-level width: 12 m.

Depth: 1.8 m.

4 control structures, as follows:

Map No.	Obj. No.	Name	Canal km.
58	92a	Lock I at Hoogstede-Bathorn	7.9
58	97	Lock II at Klein Ringe	13.7
58	103a	Lock III at Volzel	19.1
58	106a	Guard lock (Sperrschleuse) IV at Vorwald	22.1

f) Nordhorn-Almelo Canal:

The canal is located between dams in the Vechte Valley, otherwise in cut 4 m deep.

Canal bottom: Sandy.

Water-level width: 16-17 m.

Depth: 1.8-2.1 m.

1 control structure, as follows:

Map No.	Obj. No.	Name	Canal km.
58	56a	Guard lock (Sperrschleuse) at Frensdorferhaar on the German-Netherlands border	0.2

II. Peacetime Regulation and Utilization of the Flow.

The Ems R. left-bank canals are fed by ground water in the cut reaches and by several inlets from the moors through the Ems at Hanekenfaehr (Map No. 58, Obj. No. 45, see General map) and the Vechte (Map No. 58 Obj. No. 152, see General map) at Nordhorn.

Out of the Ems R. at Haneken Dam (Wehr Haneken) only 2.2 m^3/s can be taken at MW and MW, or navigation in the Ems R. and the Dortmund-Ems Canal will be impaired. Through the Haren-Ruetenbrock Canal the water flows back to the Ems R. at Haren. In the Ems-Vechte Canal and in the upper pool of the South-North Canal this is possible through both mill dams (Muehlenwehre) at Nordhorn (Map No. 58, Obj. No. 150 and 151), the lock (abschlagswehr) to the Vechte (Map No. 58, Obj. No. 152a) and Lock I on the South-North Canal (Map No. 58, Obj. No. 61). The by-pass canal (Entlastungskanal) below Lock II of the Coevorden-Piccardie Canal (Map No. 58, Obj. No. 97) drains again into the Vechte R. at Emlichheim.

High water in the Ems and Vechte Rivers is kept out of the canals by closing the inlet locks. The Nordhorn-Almelo Canal remains entirely in the sandy area (Staubereich) of the Vechte.

The principal canals crossing the German-Holland border have guard-locks (Sperrschleusen) to eliminate large volumes of water in accordance with treaty arrangements.

In addition to serving navigation with lock sizes (effective length 33 m., effective width 6.50 m) corresponding to vessels, the left-side canals serve to impound water for uses in the operation of 2 mills in Nordhorn, for cooling purposes by textile factories in Nordhorn, and for cleansing purposes by a potato-flour mill in Emlichheim.

III. Warfare changes in the flow.

By complete closure of both mill dams (Muehlenwehre) on the Vechte (Map No. 58, Obj. No. 150 and 151) and the lock (Abschlagswehres) (Map No. 58, Obj. No. 152a) and by opening Lock I (Map No. 58, Obj. No. 61a), the entire Vechte flow will be diverted to the South-North Canal. It is also possible, at Lock I on the Ems-Vechte Canal (Map No. 58, Obj. No. 45), to take out considerably more than 2.2 m^3/s from the Ems R.

With both quantities of water, some installations in the low and slightly sloping land between Nordhorn and Georgsdorf (see General map) can be inundated, because the water level in the canal is considerably higher than the surrounding land, also the water depth in the individual canal pools can be raised several decimeters by running up the lock gates.

Ems River Left-Side (Linksemsische) Canals (Sequence Downstream) DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* (Obj. No.)	Control Structure (Name & Purpose)	Pool Data: a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data: a. Lock b. Dam c. Bridgeway	Operation Effects: a. Full Closure b. Full Opening c. Accompanying Results	Remarks
1	2	3	4	5	6	7
a¹) Ems-Vechte Canal						
Hanekenfaehr 0.050 km	58 45	Lock (Schleuse) I Flood control feeding the left-side canals	b. 16 m c. max. 2 m d. 23.40 m/NN e. 21.52 m/NN	a. Masonry lock chamber with wooden miter gates; chamber length 40 m, width 6.0 m, Gate width, 6.5 m.	a. Downstream: Blocking of the inlet from the Ems River and water deficiency in the 112 km-long canals. b. Downstream: Overflowing from canal dams at HW on the Ems River. c. Shut off navigation and industrial operations. Inundation.	Destruction: Best by demolition of upper or lower gates. The pool runs empty.
Bookholt 21.2 km	58 152a	Outlet dam (Ablasswehr) Flood control Navigation	a. 23 km b. 16 m (entire canal) c. max. 2 m d. 21.50 m/NN e. [illegible]	b. Masonry dam (Wehranlage) wooden gate sills. 19.90 m/NN width 4 m	a. Upstream: Overflowing from canal dams at intensive precipitation. b. Upstream: Navigation shut off entirely. Water deficiency in the left-side canals. c. Inundation; stopping of industrial operations.	In the upper head of the old double lock (Koppelschleuse), which is out of operation, a sluice-dam installation (Schuetzenwehranlage) is located. Opening 4 m wide and 2 m high. Gate boards (Schuetztafel) are horizontal; divided into 2 sections.
a²) Connecting Canal (Verbindungskanal) between the Ems-Vechte Canal and the Vechte R.						
Nordhorn 0.7 km	58 129b	Lock (Schleuse) II Flood control against the Vechte River Navigation	a. 23 km b. 16 m c. max. 2 m d. 21.40-22.70 m/NN e. 21.50 m/NN	a. Masonry heads with iron miter gates and sloping chamber walls. Chamber length 40 m, width 6 m. Gate width 6.5 m.	a. Shutdown of navigation to Holland. b. Downstream: Flooding from canal dams at intensive precipitation. c. to b. Inundation.	
b) South-North Canal (Sued-Nord-Kanal)						
[illegible] 1.1 km	58 61a	Lock (Schleuse) I Navigation Feeding of canals	a. 23 km b. 16 m (entire canal) c. max. 2 m d. 21.52 m/NN e. 19.25 m/NN	a. Masonry lock chamber with wooden miter gates. Chamber length 33 m, width 6 m. Gate width 6.5 m.	a. Downstream: Water deficiency in the 89 km in downstream canals. b. Upstream: Emptying of canal pool. Downstream: Water-stage rises and overflows the gates of Lock II. c. Interruption of navigation.	Destruction: The simplest, from the upper and lower gates. The chamber walls of the lock, 1:8 slope with arched tops between iron forms, based on wooden piles.

*General map reference

Ems River Left-Side (Linksemsische) Canals (Sequence Downstream) DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data a. Lock b. Dam c. Bridgeway	Operation Effects a. Full Closure b. Full Opening c. Associated Results	Remarks
1	2	3	4	5	6	7
S of Wietmarschen Northern Meadow (Wiesen) 3.8 km	58 62a	Lock (Schleuse) II Navigation	a. 2.7 km b.-c. Same as Lock I above. d. 19.25 m/NN e. 18.0 m/NN	a. Same as Lock I above. c. Iron, field-path turn-bridge (Feldweg-Drehbruecke).	a.-c. Same as above. Overflowing of the gates at Lock III.	Destruction: Same as Lock I above. In the Lock sill at Lee River, back-siphon is located.
Hohenkoerben Wietmarschen 7.4 km	58 64a	Lock (Schleuse) III Navigation	a. 4.7 km b.-c. Same as Lock I above. d. 18.00 m/NN e. 16.75 m/NN	a. Same as Lock I above. c. Iron, field-path turn-bridge (Feldweg-Drehbruecke)	a.-c. Same as Lock I above. Overflowing the gates of Lock IV.	Destruction: Same as Lock I. In the lock sill a Lohner back-siphon is located. Chamber walls of the lock are the same as Lock I.
Alte Piccardie 10.9 km	58 65a	Lock (Schleuse) IV Navigation	a. 3.5 km b.-c. Same as Lock I. d. 16.75 m/NN e. 16.00 m/NN	a. Same as Lock I above. c. Iron, field-path turn-bridge (Feldweg-Drehbruecke)	a. Downstream water shortage. b. Upstream: Water stage lowered about 0.75 m. Downstream: Water stage rises. c. to a. Shut off through navigation. to b. In the upper pool only vessels with small draft could navigate.	Destruction: And chamber walls same as Lock I.
N of Rühlermoor 34.9 km	[illegible] 81a	Lock (Schleuse) V Navigation	a. 31.9 km b.-c. Same as Lock I. d. 16.0 m/NN e. 15.0 m/NN	a. Masonry heads, sloping chamber walls. Chamber length 33 m, width 6.5 m	a.-c. Same as Lock I. Overflows the gates on Lock VI.	Destruction: Same as Lock I.
N of Fehndorf 39.6 km	46 203a	Lock (Schleuse) VI Navigation	b. 12 m (at Fehndorf) c. 1.8 m (max. at Fehndorf) d. 15.0 m/NN e. 13.0 m/NN For the entire canal, same as Lock I.	a. Same as Lock V. c. Roadway 2.5 m. Load 6 tons.	a.-c. Same as Lock I. Overflows the gates on Lock VII.	Destruction: Same as Lock I. The lock-installation diversion canal is 1 m diameter, with inlet gates.
Ruetenbrock Gosebrock 44.6 km	46 209a	Lock (Schleuse) VII Navigation	a. 5 km b.-c. Same as Lock I. d. 13.0 m/NN e. 11.4 m/NN	a. Masonry lock chamber with miter gates. Chamber length 33 m. Chamber and gate width 6.5 m. c. Roadway 2.5 m. Load 4 tons.	a.-c. Same as Lock I. Overflows the gates on Lock III of the Haren-Ruetenbrock Canal.	Destruction: Same as Lock I. Of the lock-installation diversion works (1 m in diameter), and the inlet gates.

*General map reference

Ems River Left-Side (Linksemsische) Canals (Sequence Downstream) DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data: a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data: a. Lock b. Dam c. Bridgeway	Operation Effects: a. Full Closure b. Full Opening c. Associated Results	Remarks
1	2	3	4	5	6	7
c) Schoeninghsdorf-Hoogeveen Canal						
Schoeninghsdorf 2.6 km	58 / 153a	Guard lock (Sperrschleuse) Navigation	a. 31.9 km b. 16 m c. max. 2 m d. 16.00 m/NN e. 15.50-16.44 m/NN	a. Masonry heads, double-board, sloping chamber walls, miter gates. Chamber, length 36 m. Chamber and gate width 6.5 m. c. Iron, turn-bridge for vehicles.	a. Without importance. b. Depends on the water stage in adjacent canals in Holland. c.-a. Navigation to Holland shut off. b. Water can flow to Holland. Navigation possible only for vessels with small draft. Dam of sheet piling.	
d) Haren-Ruetenbrock Canal						
Haren 0.1 km	56 / 208a	Lock (Schleuse) I Guard lock (Sperrschleuse) Navigation	a. 6.7 km b. 16 m c. max. 2.1 m d. 8.30 m/NN e. 7.70 m/NN (GW) 10.37 m/NN (HW)	a. Masonry lock chamber double-board. Chamber length 33 m. Chamber and gate width 6.5 m. c. Roadway 2.5 m Load 4 tons	a. Without importance. b. Upstream: At GW on the Ems River the water stage is lowered 0.6 m. c. Through navigation shut down to a. At GW the Ems River would be navigable only for vessels of small draft. At GW Ems River water leaks into the canal.	Destruction: Best by demolition of upper and lower gates, the lock diversion works (1 m diameter), and the inlet g...
W of Haren 6.8 km	46 / 216a	Lock (Schleuse) II (Altharen-Erika) Navigation	a. 4.1 km b. 16 m c. max. 2.1 m (Altharen) d. 10.30 m/NN e. 8.30 m/NN	a. Masonry lock chamber. Miter gates. Chamber length 33 m. Chamber and gate width 6.5 m. c. Roadway 2.5 m. Load 16 tons	a. Upstream: Water stage rises slowly. Downstream: Water shortage. b. Upstream: Pool runs empty. Downstream: Water stage rises and overflows the gates at Lock I, but not when the Ems stage is higher than HW. c. Through navigation stopped.	Destruction: Same as above. Lock diversion works same. Chamber walls of the lock 1:8 with arched tops between iron forms, based on piling.
Ruetenbrock-Hintere Busch 10.9 km	46 / 219	Lock (Schleuse) III Navigation	a. 3.4 km b. 16 m c. max. 2.1 m (Altharen) d. 11.4 m/NN e. 10.3 m/NN	a. Masonry lock chamber. Same as above.	a. Upstream: Same as above. Downstream: Same as above. b. Upstream: Pool runs out to about 1 m depth. Downstream: Water stage rises and overflows the gates on Lock II. c. Same as above.	Destruction: Diversion works and chamber walls, same as above.

*General reference map

Ems River Left-Side (Linksemsische) Canals (Sequence Downstream) DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data: a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data: a. Lock b. Dam c. Bridgeway	Operation Effects: a. Full Closure b. Full Opening c. Associated Results	Remarks
1	2	3	4	5	6	7
Rueten-brock	56 / 223a	Lock (Schleuse) IV Guard lock (Sperr-schleuse) Navigation	a. 3.4 km (backwater also extends up Holland Canal) b. 16 m c. max. 2.1 m d. 11.4-12.5 m/NN e. 11.4 m/NN	a. Masonry heads, miter gates, sloping chamber walls. Chamber length 33 m. Chamber and gate width 6.5 m. c. Roadway 2.5 m. Load 6 tons	a. Without significance. b. Downstream: At high-est water levels the gates at Lock III are flooded. c. to a: Navigation shut down. to b: Navigation at HW endangered.	Destruction: Same as above. Upper head of lock has a short culvert.
e) [illegible] Canal						
[illegible] Bathorn 7.9 km	58 / 92a	Lock (Schleuse) I Navigation	a. 31.9 km b. 16 m c. max. 2 m d. 15.00 m/NN e. 15.00 m/NN	a. Masonry lock chamber same as above. c. Iron, field-road turn-bridge.	a. Upstream: At HW, water stage rises. Downstream: Water shortage. b. Upstream: Water stage lowered 1 m. Downstream: Over-flowing of gates on Lock II.	Destruction: Same as above. Relief canal for HW discharges. The inflow gates to 6b. Navigation in the South-North Canal Locks IV-V also im-possible (about 1 m water depth).
Emlich-heim Klein Ringe 13.7 km	58 / 97	Lock (Schleuse) II Navigation	a. 5.5 km b. 16 m c. max. 2 m d. 15.00 m/NN e. 13.50 m/NN	a. Masonry heads, sloping chamber walls, miter gates. Chamber length 33 m. Chamber and gate width 6.5 m.	a. At HW, water stage rises. b. Upstream: Water stage lowered about 1.2 m. c. Navigation interrupted.	Destruction is easiest by demolishing the upper or lower gates. The lock drainage works at HW discharges.
[illegible] 19.1 km	58 / 103a	Lock (Schleuse) III Navigation	a. 5.4 km b. 16 m c. max. 2 m d. 13.8 m/NN e. 11.5 m/NN	a. Masonry lock chamber same as above. c. Field-road turn-bridge.	a. Downstream: Water shortage. b. Upstream: Canal runs empty. Downstream: Water stage rises, and overflows gates on Lock IV. c. Navigation interrupted.	Destruction: Same as above.
1.5 km from the German-Holland Border [illegible] 22.1 km	58 / 106a	Lock (Schleuse) IV Navigation	a. 3 km b. 16 m c. max. 2 m d. 11.50 m/NN e. 9.40 m/NN	a. Masonry lock chamber same as above c. Field-road turn-bridge.	a. Without significance. b. Upstream: Canal runs empty. Downstream: Water stage rises. c. Navigation interrupted.	Destruction: Same as above. Chamber walls 1:8 slope, arched tops, between iron forms, based on wooden piling.

*General map reference

Ems River Left-Side (Linksemsische) Canals (Sequence Downstream)

DESCRIPTION OF CONTROL STRUCTURES

Location River km	Sheet No.* Obj. No.	Control Structure (Name & Purpose)	Pool Data a. Backwater Extent b. Pool Width c. Pool Depth d. Headwater Elev. e. Tailwater Elev.	Lock & Dam Data a. Lock b. Dam c. Bridgeway	Operation Effects a. Full Closure b. Full Opening c. Associated Results	Remarks
1	2	3	4	5	6	7
f) Nordhorn-Almelo Canal						
Frensdorferhaar 0.2 km	50 / 56a	Guard Lock (Sperrschleuse) to Holland	a. 3.5 km b. 16 m c. max. 2 m d. 21.40-22.70 m/NN e. 21.65 m/NN	a. Masonry lock chamber with iron miter gates. 2-way turning. Chamber length 40 m, width 4 m. Gate width 6.5 m.	a. Shut down navigation to Holland. b. Significant only when the water drains to Holland. c. Shortage of cooling water for 2 textile factories.	Destruction: Same as above.

*General reference map